MACHINE DESIGN

October 1952

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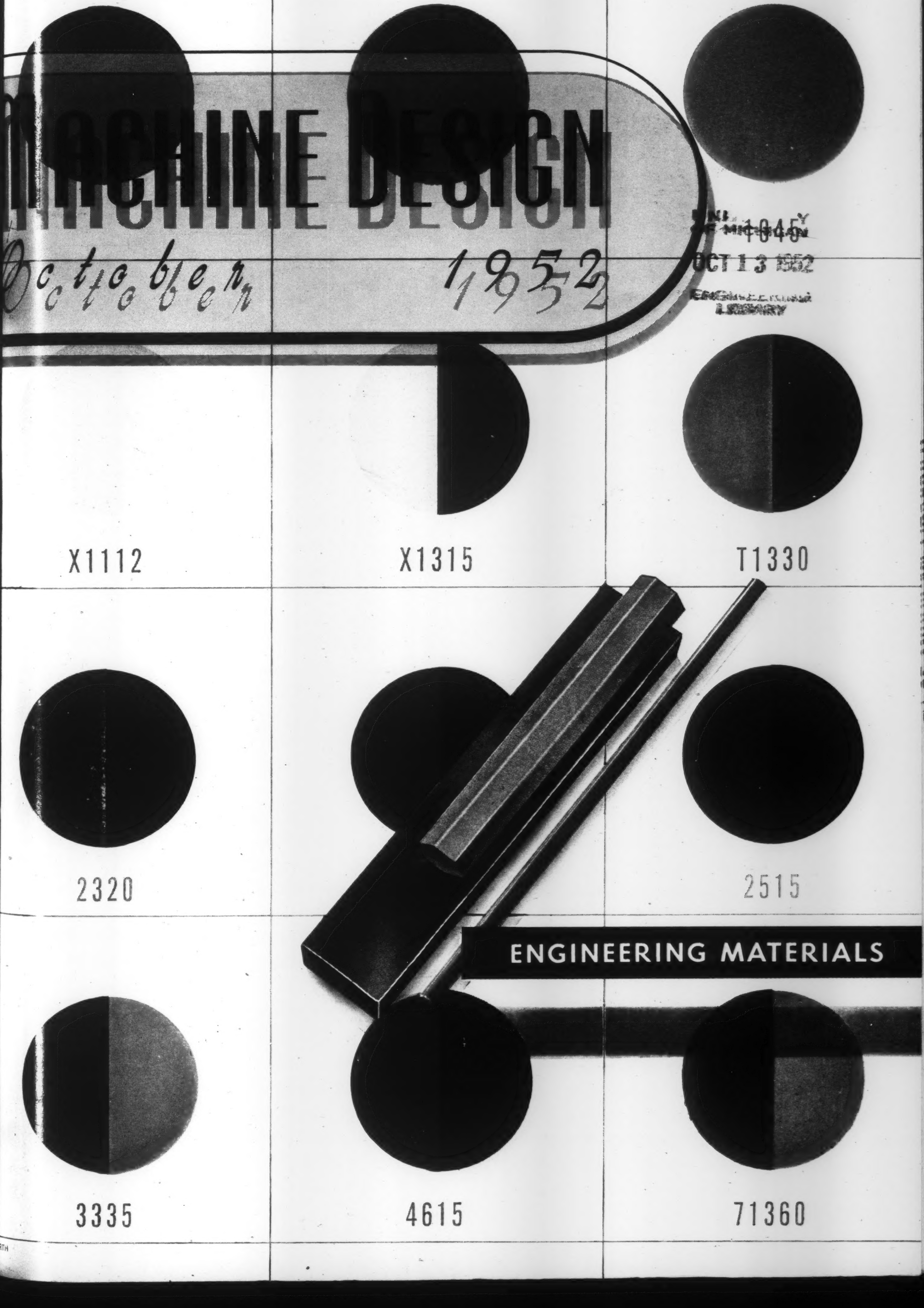
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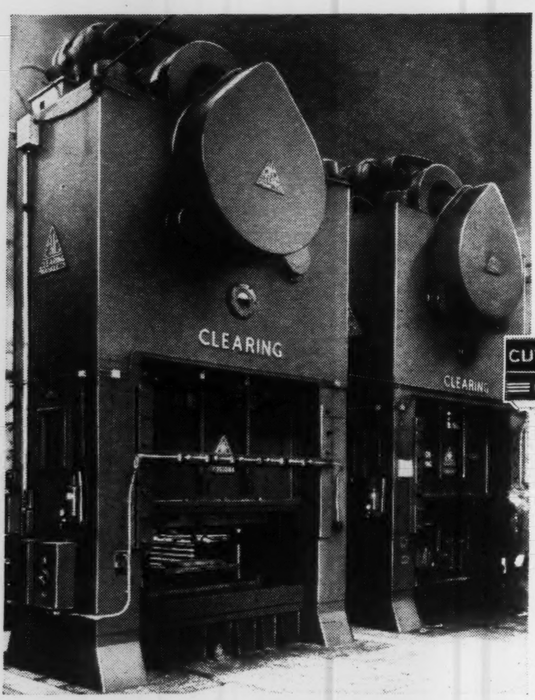

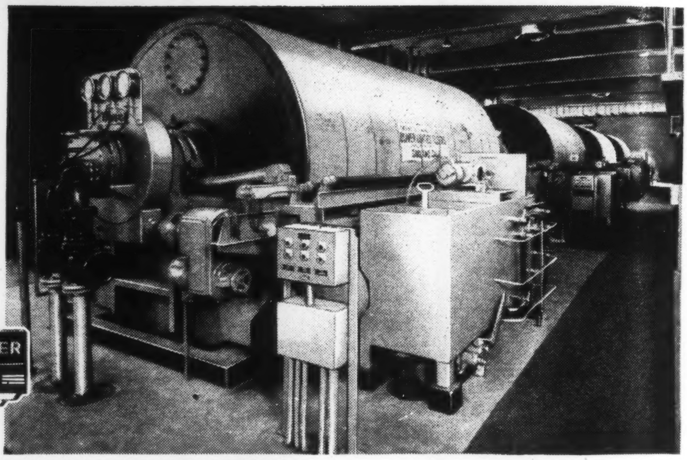

OLIVER UNITED FILTERS INSTALLED IN LARGE SEWAGE TREATMENT PLANT AND COMPLETELY EQUIPPED WITH CUTLER-HAMMER MOTOR CONTROL.

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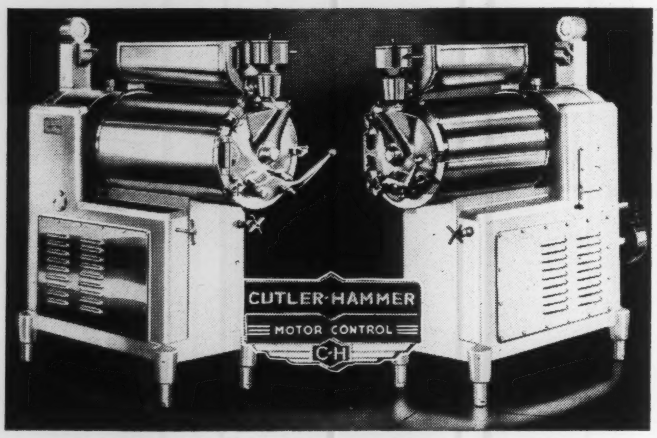

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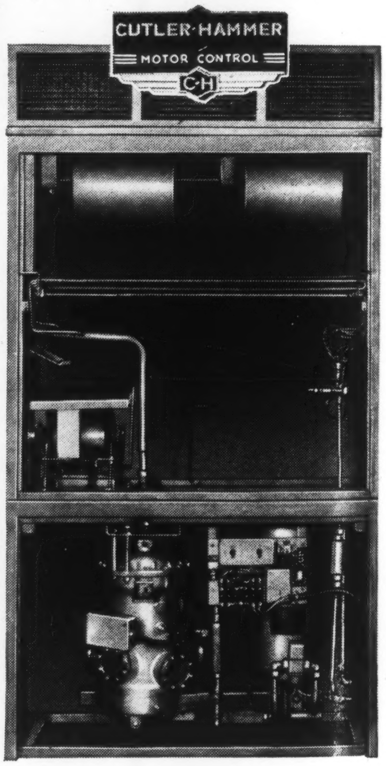

AIRTEMP MODEL 1008 AIR CONDITIONER WITH PANELS REMOVED TO SHOW MECHANISM; ONE UNIT OF COMPLETE LINE MADE BY AIRTEMP DIVISION OF CHRYSLER CORP. USING CUTLER-HAMMER MOTOR CONTROL.

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THE PROFESSIONAL JOURNAL FOR ENGINEERS AND DESIGNERS

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Over the Board

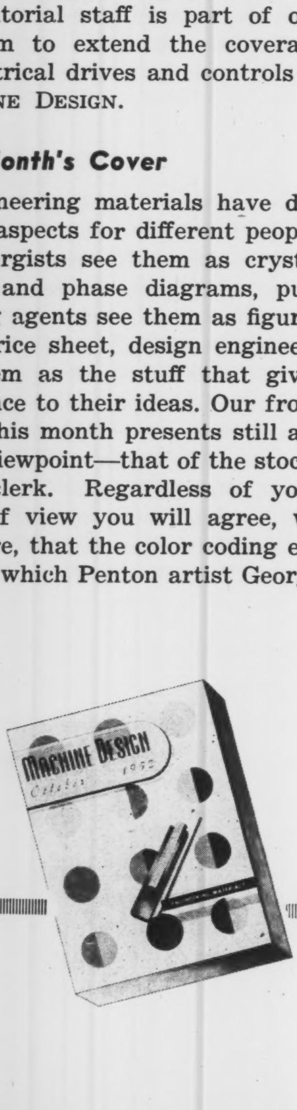
Introducing a New Editor

This month a new name appears on our "masthead" (the right-hand column on this page) — that of Keith Carlson who joined our editorial staff last month. Keith, whose picture appears on Page 220, is a graduate of Case Institute of Technology (B.S. in Electrical Engineering). Before coming with us he was in charge of the writing of service manuals for the Euclid Road Machinery Co., and prior to that was a sales engineer for the W. S. Tyler Co. During the war he served overseas as a radio operator with the 13th Armored division in France and Germany. The appointment of an electrical engineering graduate to the editorial staff is part of our program to extend the coverage of electrical drives and controls in MACHINE DESIGN.

This Month's Cover

Engineering materials have different aspects for different people. Metallurgists see them as crystal grains and phase diagrams, purchasing agents see them as figures on a price sheet, design engineers see them as the stuff that gives substance to their ideas. Our front cover this month presents still another viewpoint—that of the stockroom clerk. Regardless of your point of view you will agree, we feel sure, that the color coding examples which Penton artist George Farnsworth has arranged in an attractive design make a striking display to introduce this annual engineering materials issue.

The same pattern somewhat modified serves to introduce the feature section "Materials in Design" (Page 125) a symposium of ten articles contributed by outstanding authorities which associate editor Ben Hummel has rounded up for your enlightenment. As usual, extra copies of this section as well as of other articles in this issue are available for the asking so long as the supply lasts. Just fill out the handy postcard opposite Page 193.



A Promotion

Bob Stedfeld, who has been an assistant editor of MACHINE DESIGN since the spring of 1951, has been promoted to associate editor. Among other things, Bob has the exacting job of seeing that the magazine all fits together, with neither blank pages nor superposed pages in the editorial section. You will find his picture on Page 220 of this issue.

How Many People?

While on the subject of our own staff, we are often asked how many people it takes to produce MACHINE DESIGN. Because some devote only part of their time to this publication a precise answer isn't possible in terms of manpower, but there are 30 people devoting full time and 12 devoting part of their time to the publishing operation. These comprise the editors and artists who create the editorial pages, the salesmen, and the circulation people who see that the magazine gets into the right hands.

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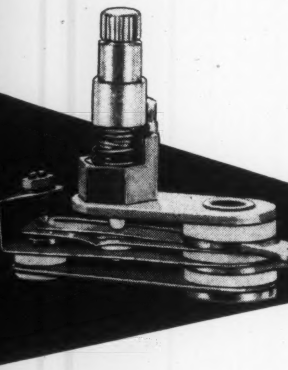

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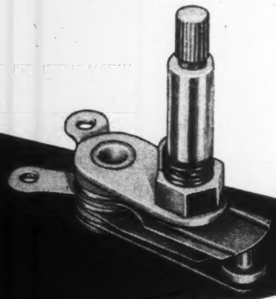

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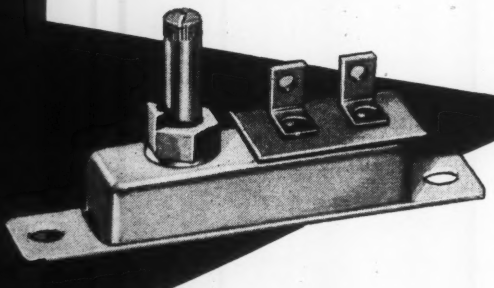

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OCTOBER 1952

MACHINE DESIGN
October 1952

Tomorrow's Materials in Design

WITH the continuing easing of material controls, there is a common feeling that a return to past freedom in materials specification seems to lie ahead.

Perhaps this conclusion is not unduly optimistic, but it is far from complete. A longer look at the problem may reveal some qualifying factors that will of wisdom or necessity moderate customary practices in the consumption of engineering materials.

One basis for adoption of a broader attitude is the recently issued Paley Commission report, *Resources for Freedom*. From the many details presented, two points stand out: (1) Within the last ten years, this country passed from a surplus to a deficit status in raw materials, and (2) over the next 25 years, demand for metals, fuels, and nonmetallics will rise about 90 per cent.

Although somewhat ominous, these factors alone do not deny future freedom in the selection and use of materials but they certainly call for some constructive long-range thinking. An intelligent program for the future introduces no new or revolutionary concepts. Principles exploited in the recent past point the way rather well, though the accents may be different.

Substitution at any cost, born of dire necessity, may be abandoned in the near future but common sense recommends continuation of two other practices: avoiding overdesign in quantity and quality of material, and designing toward materials with improving futures—away from those likely to be in critical supply.

Tomorrow's materials in design—and their availability—depend upon the design engineers who specify materials as much as upon the men who develop and produce materials.

Ben Hummel

ASSOCIATE EDITOR

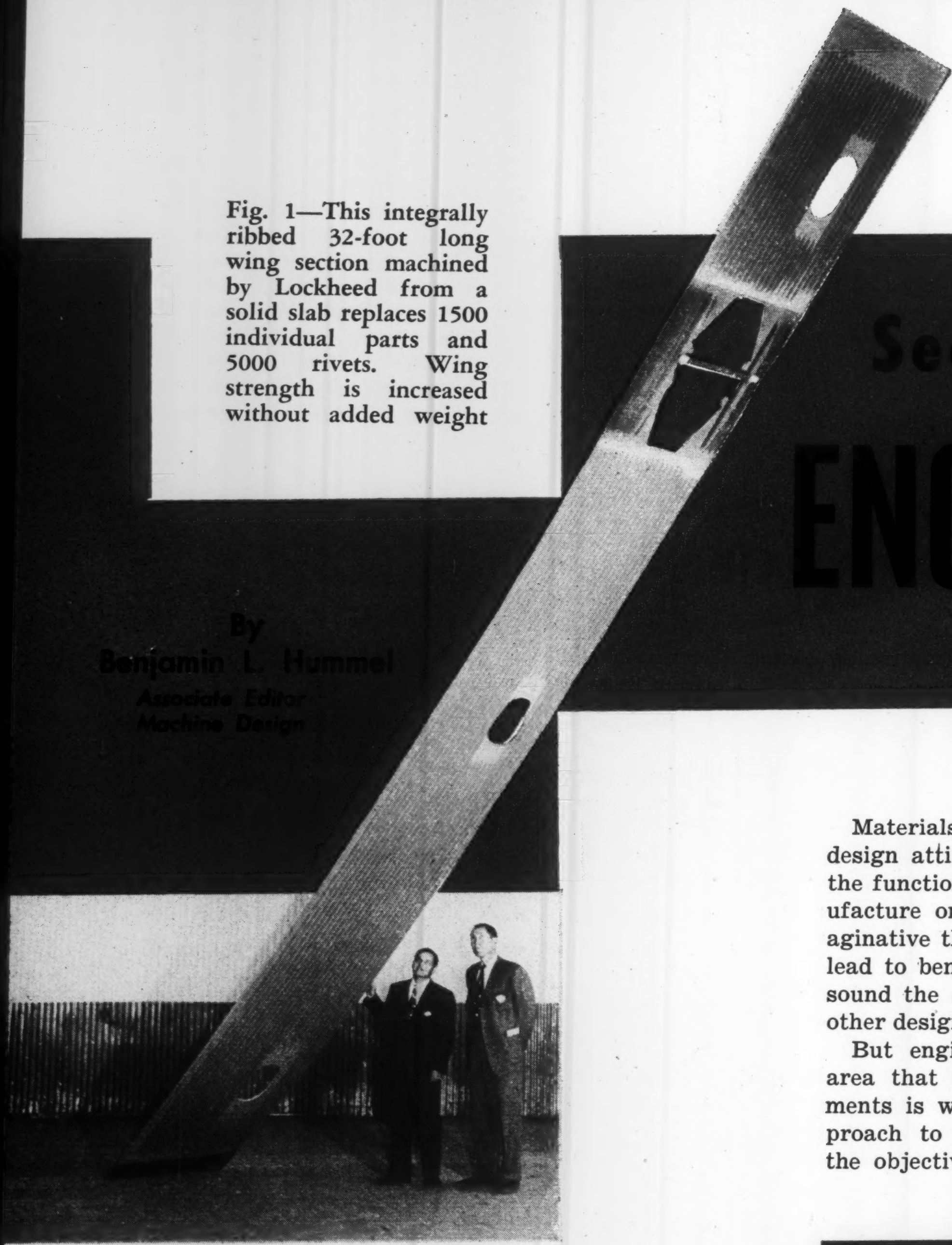


Fig. 1—This integrally ribbed 32-foot long wing section machined by Lockheed from a solid slab replaces 1500 individual parts and 5000 rivets. Wing strength is increased without added weight

Seeking New Op
ENGINEERIN

By
Benjamin L. Hummel
Associate Editor
Machine Design

PLANNING the required function of a machine so that its performance specifications are satisfied is the first requisite of design, of course, but successes of total programs are being strongly influenced by two other essentials—materials of construction and the processes of manufacture. Engineering design today owes much of its success to the continuing gain in this comprehensive thinking of the profession.

The interdependence of these three factors in design is inexorable, but no limitation is imposed. Instead, the closer function, material, and process are brought into focus as a common issue, the greater is the overall product improvement, *Fig.* 1. How well this fundamental tenet is observed is a large factor in the success of a manufacturing enterprise operating in a competitive market.

Materials are the keystone in this comprehensive design attitude. They are the physical expression of the functional design, they must be amenable to manufacture on the best possible terms. And often, imaginative thinking and alertness in this direction can lead to benefits otherwise impossible, no matter how sound the exercise of judgment within the range of other design procedures.

But engineering materials constitute so vast an area that keeping posted on all pertinent developments is well-nigh impossible. A complementary approach to the problem—one that perhaps clarifies the objectives of the search and stimulates creative

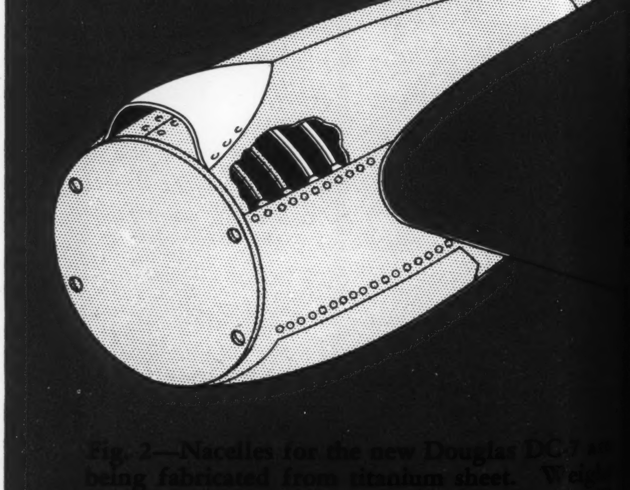


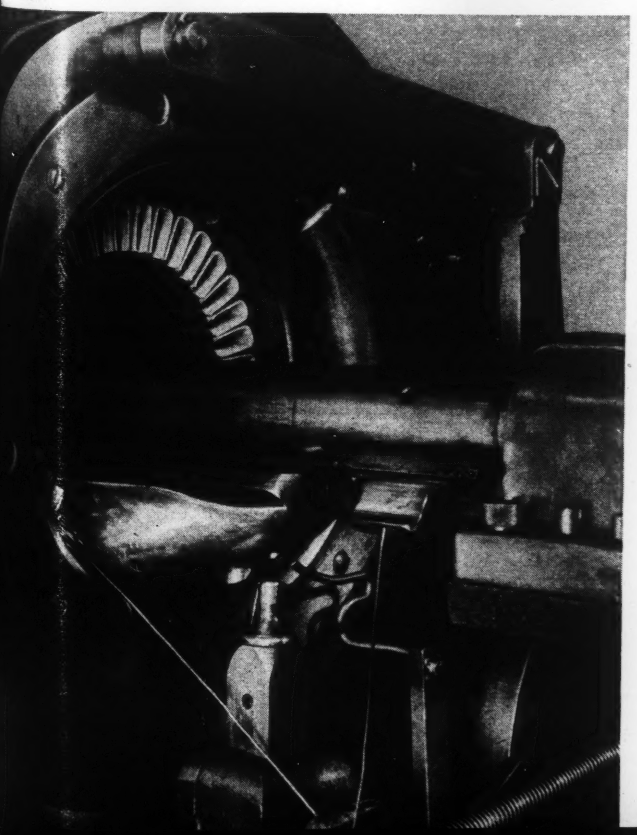
Fig. 2—Nacelles for the new Douglas DC-7 a being fabricated from titanium sheet. Weig savings of about 200 pounds per plane wi result from this single application of titaniu

nities in ATERIALS

thinking—is to look at materials from a number of specific viewpoints. These directions of thought embrace not only new materials, but also concepts relating to the most effective utilization of materials. In this later sense, again, the function to be performed by the material and the production processes available are often inseparably linked.

In this article some of the directions toward which to look for potentials in material adaptation are suggested. But more important, these proposals represent a line of thinking that can be extended and applied in specific design environments.

Ideas here presented and demonstrated by examples have been generated by two types of sources: The aircraft industry and a large manufacturer of diversified consumer products and capital equipment. North American Aviation Inc., Lockheed Aircraft Corp., and Douglas Aircraft Co. have contributed examples from the one category, Westinghouse Electric Corp. from the other. In different ways, these two types of industries—and the specific companies—exemplify advanced materials-engineering thinking.



New Materials: It might be said that design creates new materials, for often the designer's demands for particular properties or attributes in new products spur the development of new materials. Seldom, however, can the development of a completely new material for a specific application be assigned within one designer's sphere of influence. The more practical procedure—and by far the most common—is to adapt the general developments motivated by the cumulative demand of many potential applications, including perhaps his own. And certainly, with respect to minor changes in a material's properties, the designer often has the power to influence modifications of standard materials, old or new, so that they better suit his particular design.

Perhaps the most outstanding example of the effect of cumulative demand upon development of a new material is titanium and its alloys, *Fig.* 2. Although far removed from immediate application to many common uses, titanium in its combination of qualities certainly justifies a continuing awareness of its status as a new potential in design. The primary impetus in this program is the demand for high strength-to-weight ratio material for aircraft application, coupled with favorable high-temperature properties and corrosion resistance. Wherever these same attributes may be requisites in design, titanium and its alloys bear watching against the day when availability, cost and producibility come into balance with the conditions of a particular design.

Extreme conditions of service often promote development of materials other than those intended for structural purposes. For example, Douglas Aircraft reports adoption of a new synthetic hydraulic fluid, Skydrol, which is an ester base fire-resistant material. In this case, a nonpetroleum base fluid was desired to decrease the hazard of fires in the event of accidental release of fluid from aircraft hydraulic systems and cabin supercharger drive systems.

But for every creation of one totally new material, there is a multitude of refinements and modifications

Fig. 3—Left—Processing conditions often influence development of new materials. Westinghouse has compounded a new enamel wire insulation to withstand the abuse of mechanical coiling such as in this stator winding operation for a fracitional horsepower motor

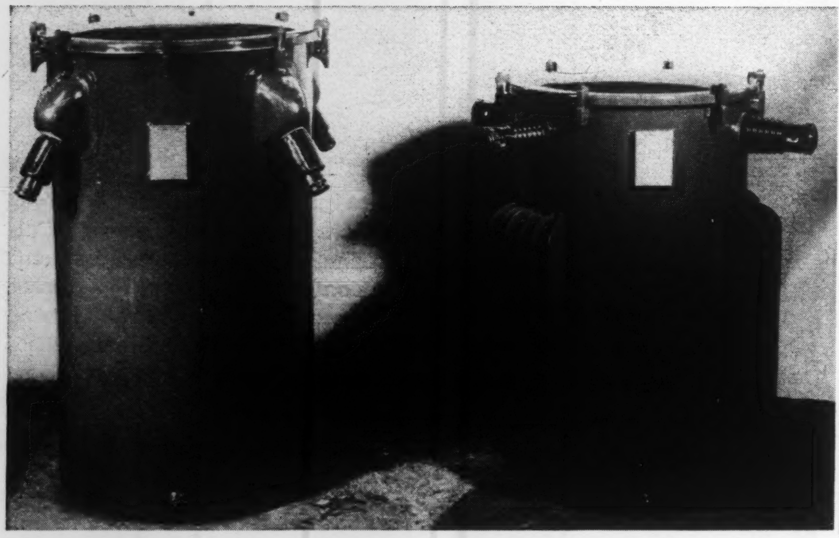


Fig. 4—Special-purpose electrical alloys such as the "oriented" steels yield gains typified by this comparison of two 30-kw constant-current regulators. In the new transformer at the right, weight and quantity of oil are less, and full-load efficiency is greater

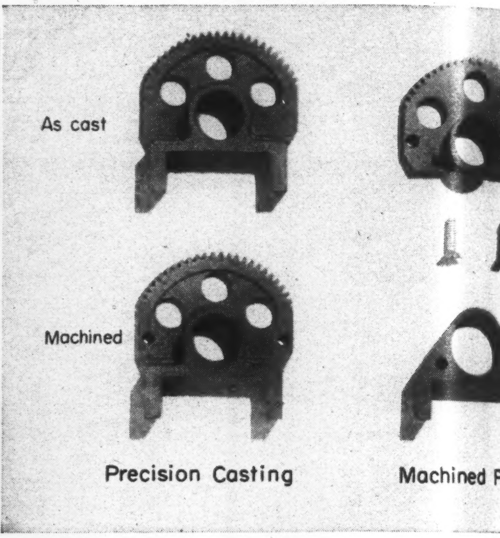


Fig. 6—Besides versatility in materials selection, such processes as precision casting can often show gains in producibility, as exemplified by this Westinghouse gear sector

in basic material types. In less dramatic fashion perhaps, but certainly no less significant in overall effect, such advances contribute to design improvement. Evolution of new alloys of steel, aluminum and magnesium, variations in plastic and rubber types, and a host of other subjects mark this more subtle course of innovations in materials.

From such obvious directions—the new and the improved—appear opportunities in materials selection, and often they come to the designer's attention with little effort on his part. But normal channels of information might often be enlarged if curiosity and alertness are sharpened.

Perhaps usual sources of materials development and supply occasionally fail to meet a need arising from conditions of a special sort. It may be that the probable consumption of the projected new material is limited, thus deterring investment in development and facilities by external sources. Just as often, though, the situation is that cited by J. B. Seastone, manager of materials engineering at Westinghouse: At times, a materials problem is best solved by being next to it. Having intimate knowledge of the requirements to be satisfied is a requisite and being subjected daily and directly to the challenge of the problem is often the stimulus.

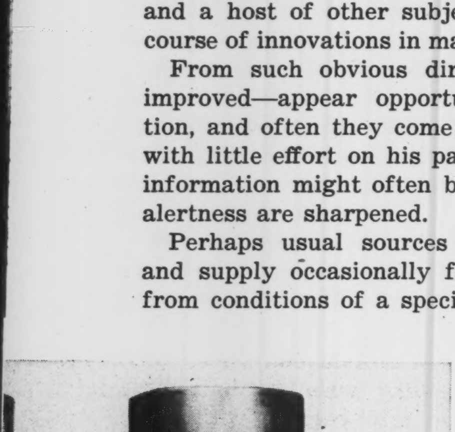


Fig. 5—Changes in both material and process for this capacitor can resulted in light weight, lower cost, and corrosion resistance. An aluminum extrusion replaced a steel can with welded bottom

Enamel wire insulation is an example of a problem approached in this way at Westinghouse. While materials adequate for insulation were available from outside sources, some properties were not best suited to the rigorous handling of the wire in production. Besides insulation properties and heat resistance, toughness and flexibility were required of the enamel to withstand conditions encountered in automatic coil-winding operations, *Fig.* 3. Research and production development within the organization are yielding a new and better answer.

The joint development by Westinghouse and Armco of the "oriented" electrical steels typifies again the special-purpose special-material approach. With crystal structure of the new steels oriented to favor required magnetic properties, more capacity could be packed into the same space or a unit of comparable rating would occupy less space, *Fig.* 4. Adoption of the oriented steels, though, necessitated redesign of products to take full advantage of the new material; functional design had to be adapted to the material.

Alternate Materials: The labels "alternate" or "substitute" applied to materials often connote a disparity between the performances of the original and the alternate. Perhaps the inference is often valid over such periods as that of the last two years when shortages have been acute. But, out of such experiences are arising constructive attitudes that are elevating some so-called substitute materials to a regular status.

The theme of substitute and downgrade should be food for active engineering thought at any period. But perhaps the case might gain favor if stated less negatively—*upgrade* the performance expectation of materials. Utilization of materials possessing far greater potential than demanded by the expected service is an engineering luxury that should be regarded as intolerable in normal times as well as in critical periods.

Alloy steels are good examples of the possibilities in this direction. Essentially the boron steels represent effective upgrading of alloy-steel performance. Usual alloying elements in smaller proportions—with boron—provide comparable hardenability and strength ranges. Some few farsighted companies recognized the practicality of this approach even before World War II and worked successfully toward adoption of boron steels in full production. The recent need to conserve critical elements has forced many to take the same course of action, and widespread use of boron steels as regular rather than emergency alloys will probably grow.

Improved heat treating can also play a part in upgrading the performances of lower alloy steels. For example, Lockheed is exploiting advantages to be gained by heat treating low-alloy steels to a strength range of 260,000 to 280,000 psi in new designs for landing gear components and other parts where weight savings can be realized. Toughness is not sacrificed, but some factors are more sensitive than for high alloys and control of processes must be more accurate.

Growing use of aluminum in many applications previously reserved for copper is another example of how a substitute material is finding well warranted adoption as a permanent alternate. Such a trend results simply from the intelligent definition of the desirable areas of application of different materials, although again it has taken an emergency to stimulate action.

Alternate use of aluminum is worth investigation where electrical conductivity is the requisite, rather than heat transfer. A conductor of aluminum must be larger than one of copper, but despite the added size it weighs and costs less. Hence, where space is not limited, aluminum is proving effective. Such transitions frequently cannot be made, however, without the need to learn how best to work the material. Joining of aluminum, for example, is more difficult, but suitable techniques are known or are being developed. On the other hand, Westinghouse has found that for some types of electrical equipment the added volume of aluminum in the heart of the unit would require such enlargement of the surrounding elements that total material required and overall cost would increase prohibitively.

Alternate Processes: It is no anomaly that production processes influence more effective materials selection and utilization. Actually this direction of attack is one of the most fruitful in showing day by day gains in the overall manufacturing operation.

A singular demonstration of how materials and process can be combined to advantage is provided today by the relatively new shell-molding technique. Thin phenolic-binder sand molds yield castings of far greater accuracy and surface smoothness than conventional sand molds. Additionally production of the resin-sand shells is readily adaptable to high-speed methods. Cost savings both in casting and subsequent machining are great. But of equal significance is the impact of the process upon the re-evaluation of materials previously found unsuited in cast form.

In many applications, for example, fabrication from sheet or plate replaced sand castings in the past primarily because of requirements relating to accuracy, finish and cost. Now, as is the case at Westinghouse, many such designs are being restudied in the light of the far more favorable conditions accompanying the new casting technique. Since the process is applicable to all cast materials—iron, bronze, steel, aluminum, etc.—avenues in many directions are opened for reappraisal of castings. Further developments in techniques and equipment can be expected to make shell molding even more attractive within the next few years.

Even in very simple components there are often

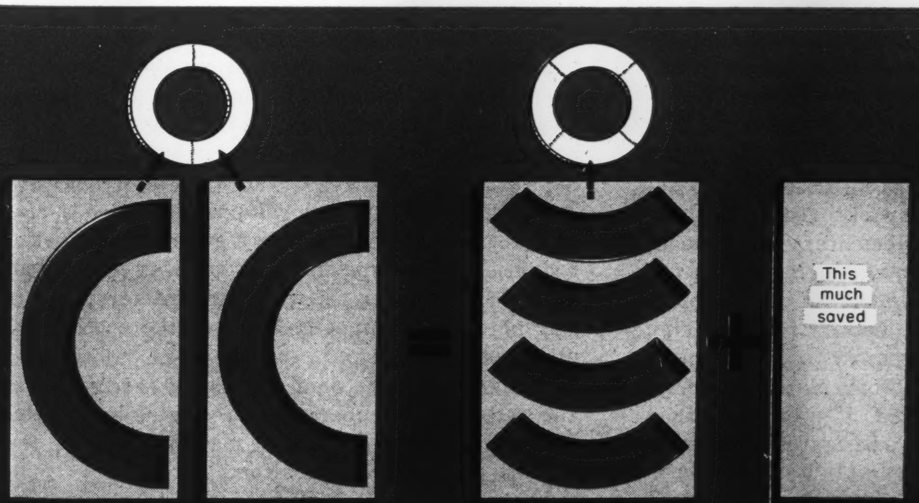


Fig. 7—More efficient utilization of materials might be achieved by extension of an elementary principle demonstrated by this redesigned turbogenerator ring. Savings in steel plate exceeded additional welding cost

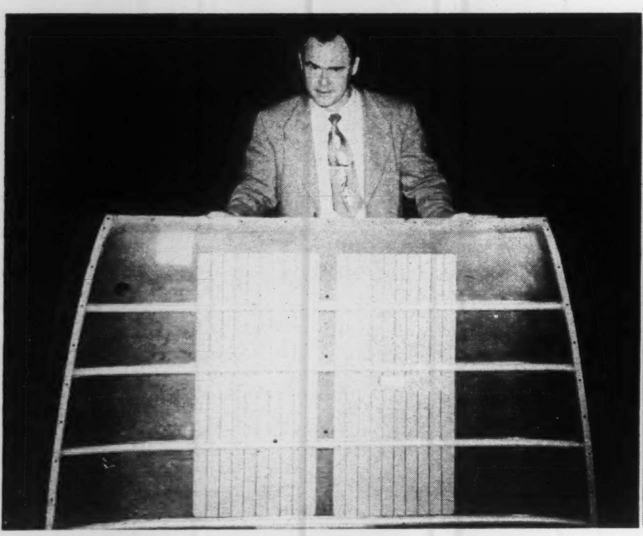


Fig. 8—Three materials in combination contribute to an improved construction. This Lockheed antenna consists of metal-sprayed cloth laminated into the plastic dome

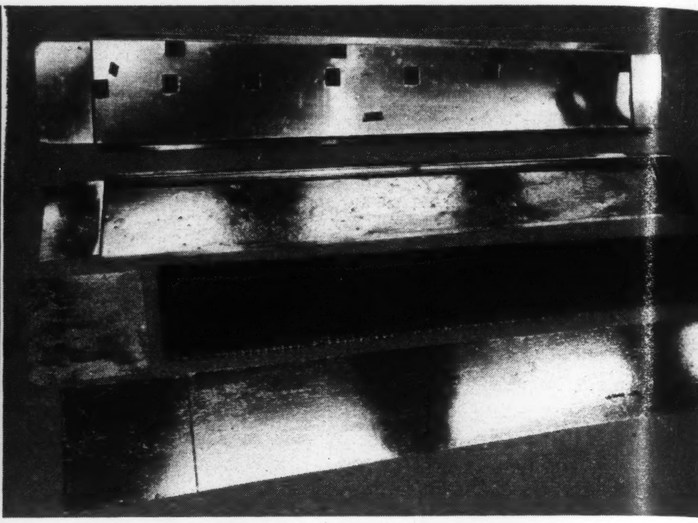


Fig. 9—Although the components of this aircraft aileron access door are an aluminum alloy, honeycomb sandwiches can be built up of many combinations of core and face materials

gains to be seized in altering both material and process. Westinghouse, for example, has redesigned capacitor cans, formerly a two-piece welded steel design, so that they are now extruded in one piece from aluminum, *Fig.* 5.

Such processes as powder metallurgy and investment casting often offer opportunities for wide ranges in materials selection as well as certain advantages in producibility, *Fig.* 6.

Matching functional requirements with material and process demands a sorting and sifting of many factors, rather than a hasty selection of the obvious or the conventional combination. The assortment of materials and processes available is so enormous that even when it is trimmed of the obviously unsuitable, several probable practical solutions usually remain. At this stage, joining well developed facts with sound judgment often leads to better design in all of its aspects.

Material Shapes: Frequently the question in design is not only what material, but what form? Tubing, strip, bars, rods, sheet, etc., are all commonplace, but is best advantage always taken of the available forms? Also, are there any new or unusual possibilities for more effective design procedures in this direction?

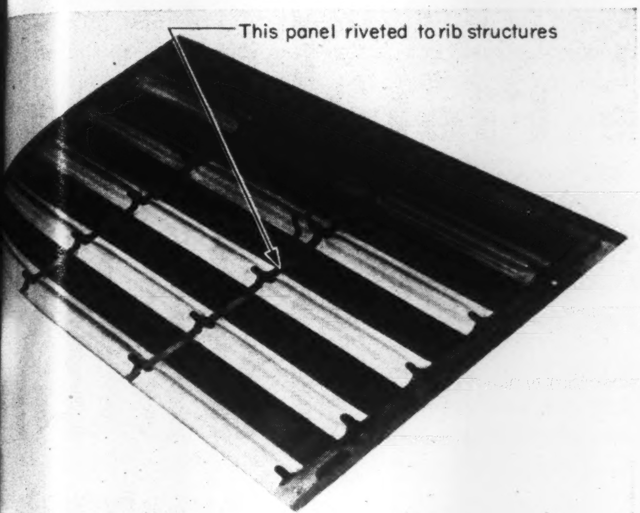
A relatively simple problem often arises in the design of parts to be stamped or cut from sheet or plate, as demonstrated in the elementary example of *Fig.* 7. In this case at Westinghouse, a ring for turbogenerators was originally designed as a two-piece welded assembly. To conserve material the design was changed to a four-piece assembly to permit more efficient cutting of the parts from plate. Although higher welding cost was incurred, it was more than offset by reduced material cost, and material supplies were extended.

Perhaps the earliest use of special-shape stock occurred in the clock industry. The advent of so called pinion wire was one of the developments marking the initiation of high-volume production in the early days of the industry. Pinions were produced with fewer operations and at lower cost from the wire to which the contour of the gear teeth had already been imparted. Still in common use for many applications, this early special-shape stock characterized some of the chief advantages accruing from special shapes obtainable in a variety of materials today.

Extruded shapes of almost all the common nonferrous materials offer unique possibilities in design. Aluminum, magnesium and copper-base alloys, some of the carbides, and many plastics and synthetics are readily extruded continuously in an infinite variety of shapes.

Opportunities in this direction will be even greater as techniques and facilities are perfected for materials heretofore unsusceptible to continuous extrusion. Development work with steel extrusions, for example, has reached a favorable status and may soon lead to their common availability. One of the most promising techniques being watched by Westinghouse engineers was initiated in Europe and is being further extended in this country by U. S. Steel Corp. In this process the severe need for adequate lubrication at the extrusion die is being met by molten glass. The implications of such developments are far-reaching. When reduced eventually to a common production procedure, steel extrusions will have all the advantages of rolled steel shapes with far greater versatility in available shapes at a fraction of the tooling and setup costs.

A significant factor in the use of extrusions, besides the reduction in operations required in the finishing of a part, is the low loss in material—a gain in terms of both cost and conservation.



g. 10—Adhesive bonding of rib sections to skin, own in this Lockheed all-magnesium-alloy panel, aracterizes another type of design where different aterials might be combined to perform different functions to best advantage

Combination Materials: Use of different materials combined, without loss of individual identity, to perform the function conventionally fulfilled by one is becoming a practical and profitable concept. The aircraft industry has been particularly prolific in this practice because of the critical demand for optimum component properties at the lowest possible overall weight.

This concept is demonstrated in an unusual manner by a Lockheed antenna design, *Fig.* 8. The aircraft antenna is actually metal sprayed on glass cloth which is laminated into the plastic dome.

Honeycomb construction is another example, *Fig.* 9. Rigidity and strength are imparted to a component by the lightweight honeycomb core of aluminum, stainless steel, glass cloth or paper, and surface requirements are met by wood, metal or plastic facings. Adhesives and techniques have been developed to provide adequate "peel" strength in such assemblies. Panels of this construction are being widely used in the aircraft industry and advantages are also being exploited in other transportation fields.

In a somewhat anologous fashion, sheet metal panels are being stiffened by contoured ribs bonded to the "skin," *Fig.* 10. Use of materials in combination permits each to meet specific requirements without compromise; rigidity is provided with least material weight, surface needs are met by thin sheet of the desired material.

Other obvious possibilities occur with metallics, such as in the various combinations of clad metals. Also, in both high and low-pressure laminated plastics, the possible combinations of material and properties are attractive avenues of investigation.

Materials Standardization: Just as some problems are solved by use of dissimilar materials, so might advantages be gained by specifying the same materials for different applications. The well known benefits of standardization apply well to engineering materials, but often the possibilities are overlooked because the effects of standardization are not felt as directly in design as they are in other areas of the manufacturing operation. Standardization of materials usually means reduction of inventory and stocking facilities, easier availability, and greater similarity of processing details. Inspection may be reduced and paper work is often cut.

Standardization might be applied to both of the two chief material factors: composition and size. At Westinghouse compositions of some material types are kept to an absolute minimum because of production volume involved. That is, if the most desirable materials were stocked for each application, the quantity required for each would be too low to purchase except at premium price, and inventory details would become cumbersome. Instead, a limited number of standardized compositions are stocked, and qualities so compromised for some applications are effectively regained by special heat treatments or other processes. Such special handling would be prohibitive on high-volume components but is justified in low-volume production.

Standardization on a minimum number of stock sizes is good practice whether high or low volume is involved. In this type of activity, preferred numbers can often be applied with great advantage. Preferred numbers might be thought of as a basic code underlying standardization of any factor expressible in numbers. Through its use, successive sizes in an assortment of any range are intelligently spaced at a constant percentage interval to provide the minimum sufficient number of sizes.

Whether the designer is responsible for specifying purchased stock size or not, he definitely influences size and is often in a position to promote standardization in this direction.

Summary: The ideas presented in this article might be summarized by these injunctions:

1. Watch new materials
2. Examine alternate material possibilities
3. Look into alternate processes as means for more effective materials utilization
4. Investigate preshaped materials such as extrusions
5. Attempt to match diverse requirements with combination materials
6. Review and standardize material types and sizes.

These directions of attack might well be extended and subdivided, but one overriding theme must be kept constantly in mind—function, material and process are integral in design.

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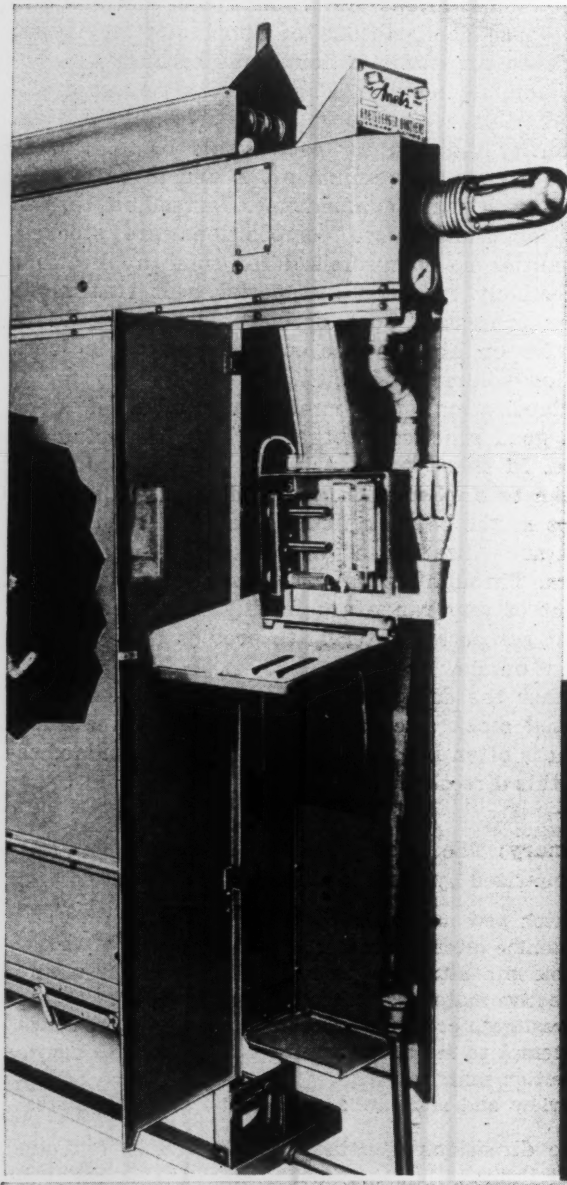
North American Aviation Inc. .... A. T. Mocium

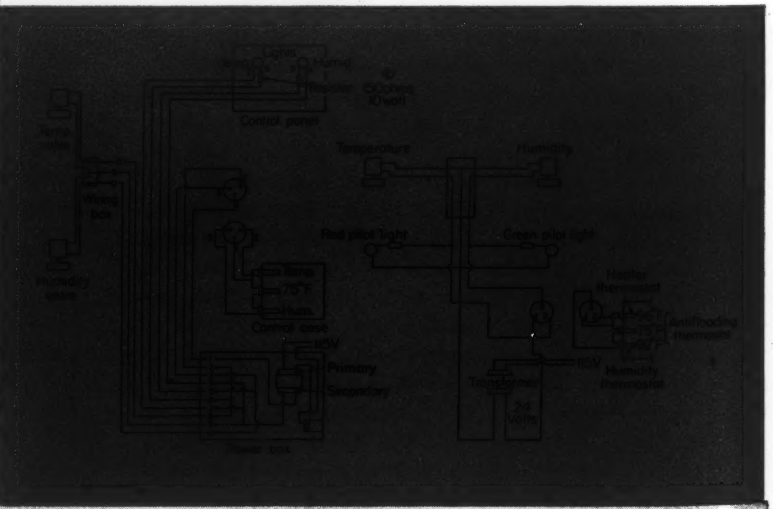
SCANNING the Field For Ideas

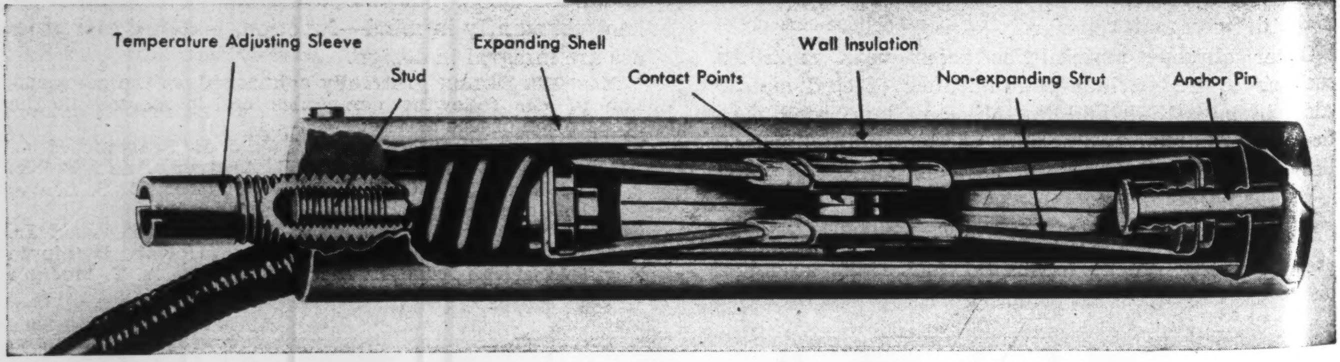


Novel humidity control, employing three sensitive thermostats to regulate both the temperature and relative humidity, is employed in the proofing cabinet shown at left. This cabinet is being used to maintain a temperature of 96 F and an 86 per cent relative humidity in the baking industry to provide a controlled atmosphere for raising yeast doughs.

Cover for the control is open to show the three thermostats, one of which is sectioned below to show its principle of operation. Manufactured by Fenwal Inc., it utilizes an expanding shell to open and close electrical contacts mounted on nonexpanding struts which are attached to each end of the temperature-sensitive shell. Control circuit for the cabinet, manufactured by Anetsberger Bros. Inc., is shown in the schematic wiring diagram below.

The uppermost thermostat in the control acts as a temperature regulator and its contacts are set to open at 96 F. It controls a solenoid-operated steam valve, permitting steam to enter the heating coils in the proofing cabinet


Lights
Temp
Humid
Resistor
150 ohms
10 watt
Control panel
Temp valve
Wiring box
Humidity valve
Temperature
Humidity
Red pilot light
Green pilot light
Temp.
75°F
Hum.
Control case
115V
Primary
Secondary
Power box
Heater thermostat
96°F
75°F
92°F
Antiflooding thermostats
Humidity thermostat
115V
Transformer
24 Volts

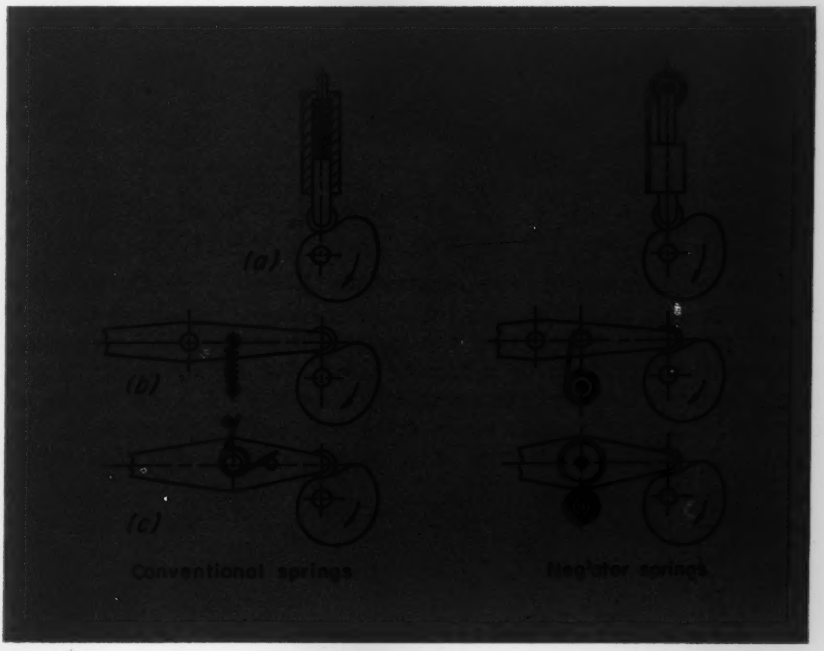

Temperature Adjusting Sleeve
Stud
Expanding Shell
Contact Points
Wall Insulation
Non-expanding Strut
Anchor Pin

when the temperature falls below the desired level. A red pilot light indicates when the heating circuit is in operation. The bottom thermostat is wrapped in a self-feeding water saturated wick.

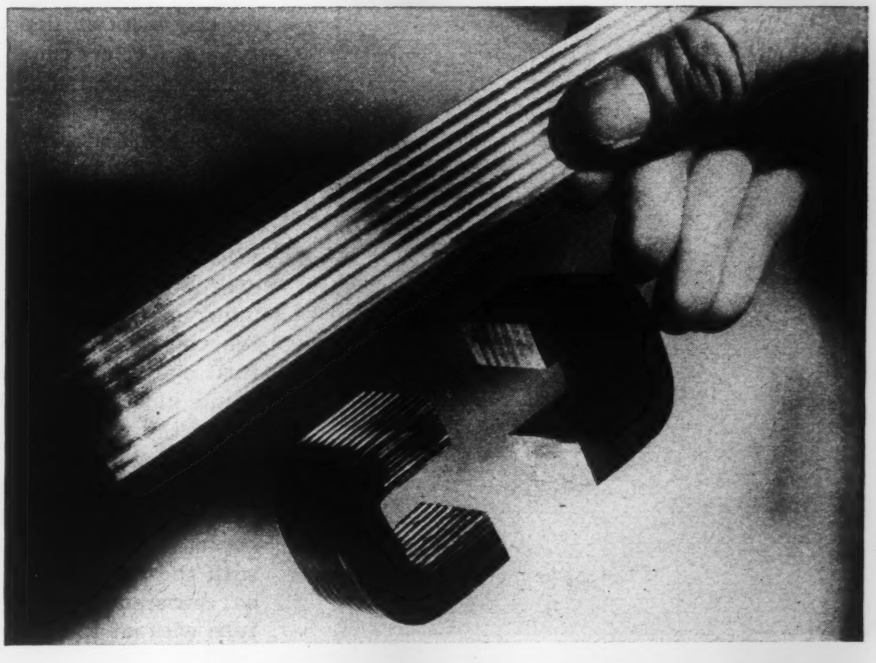
This wet-bulb unit is set at 92 F, the temperature that corresponds to a relative humidity of 86 per cent. When the humidity falls below that level, the increased evaporation rate from the wet wick lowers the temperature of the wet-bulb, closing the thermostat contacts which actuate a solenoid which turns on a steam jet. Steam is dispersed through the cabinet until the wet-bulb reaches its operating temperature, operating the controls to close the steam jet. A green pilot light is extinguished to indicate that the humidity circuit has ceased to operate.

The middle thermostat in the control serves as an antiflooding control. It is in series with the humidity steam solenoid and the wet-bulb unit and prevents the operation of the solenoid until a cabinet temperature of 75 F is reached. This arrangement prevents the introduction of steam into a cold cabinet, a condition which would cause immediate condensation of the steam on all surfaces with subsequent flooding of the cabinet and spoilage of the product. Sensitivity of the thermostats in this control is rated at plus or minus 0.1 F.

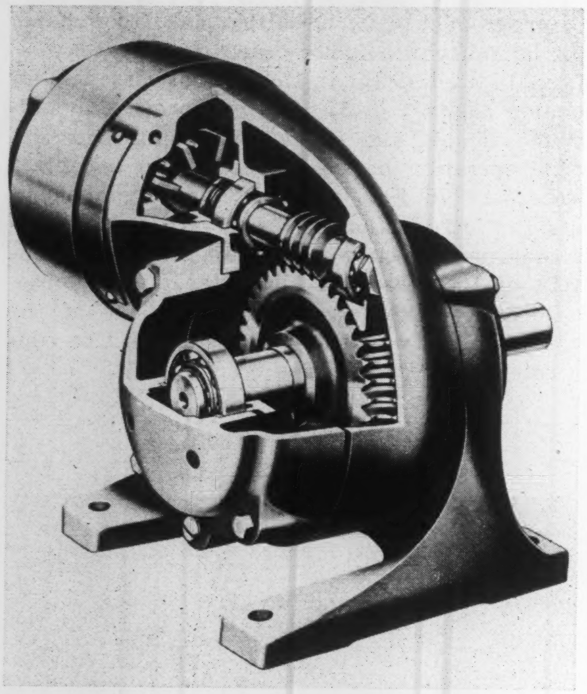
Constant-pressure springs of the neg'ator type apply uniform load on the cam drives illustrated at right, producing the minimum load which assures proper contact with the cam at all positions. This constant pressure is just sufficient to overcome friction and maintain continuous contact at any length of radial travel on the cam contour. Developed by Hunter Spring Co., these coiled springs require less space than conventional springs. As shown in view *a*, the compression spring usually has a free length of twice its maximum deflection. Regardless of travel of the neg'ator, however, it may be a tight coil and only long enough for the maximum travel. In view *b* is a similar application replacing an extension spring and in view *c* replacing a torsion spring.



Corrugated steel strip when wound into cores, right, provides added strength to specialty and electronic transformers. Hipersil, a grain-oriented steel, is slightly corrugated before being wound into a core so that it lies on itself in a compact and tightly integrated mass. The additional mechanical strength of the core afforded by the ribbed design maintains more perfect C-sections both when the core is cut apart for assembly with the windings and during transformer operation. The etched surfaces remain in intimate contact, resulting in a low-reluctance magnetic path and a low-loss butt joint. These cores, manufactured by Westinghouse Electric Corp., have the same sizes and tolerances as nonribbed cores.



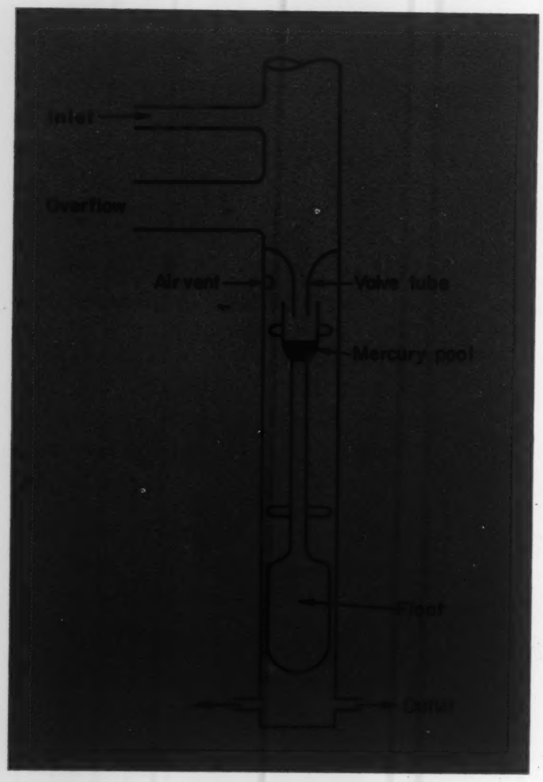
Ideas



Gear alignment in the gearmotor illustrated above is maintained by utilizing the cantilever principle of mounting the gear case on a flange-mounted base to minimize the distortion sometimes developed in separately mounted castings. This right-angle worm drive designed by U. S. Electrical Motors Inc. provides a "short-hitch" and compact hook-up, increasing the rigidity of the drive and facilitating application in close quarters.

All worm thrust on the motor shaft is taken by a heavy-duty, deep-groove ball bearing which is locked against axial movement. The dead-end bearing, opposite the take-off shaft end, is securely clamped to eliminate end play and is shimmed to locate the gear with respect to the worm. Churning of the lubricant is avoided by locating the worm above normal oil level, the level being high enough to dip the two bearings on the take-off shaft. The driven gear carries lubricant to the worm where it is thrown in all directions and penetrates into the worm shaft support bearings.

The gear case is flange mounted to both the motor and foot bracket. Being mounted with four bolts, the base may be rotated to any one of four positions for base, wall or ceiling mounting without disturbing the gear lubrication. Also, to meet space requirements, the motor may be swung to either vertical position, shaft seals preventing lubricant from entering the motor. Likewise, seals on the output shaft allow it to be mounted vertically downward, the oil lubrication resting in the bottom of the case with the gear slightly submerged.



Constant-level device, left, employing a mercury valve is noteworthy both for its simplicity and dependability. Designed by D. E. Couch and Abner Brenner of the National Bureau of Standards for maintaining constant levels in electroplating baths, it can be made easily for any size and for any solution depth.

This leveler employs a water inlet and an overflow to maintain a constant head. The mercury valve, attached to a float, allows the water to flow into the bath if the level is lowered and prevents flow outward when the level of the bath rises. This latter feature saves the solution when a large object is placed in the plating bath.

Inlet and overflow connections are at the top of the device. Just below the overflow connection, the tube is sealed except for a smaller-diameter open tube which connects the upper section to the lower section of the tube and serves as the valve seat. An open cup of mercury supported by the float opens and closes the valve according to the height of the liquid in the bath. When the bath level rises the mercury closes the valve and all the water entering through the inlet is rejected through the overflow.

None of the dimensions of the leveler are critical; however, the tube should be of sufficient size that it will not become clogged by small particles of sediment that may enter with the water. The mercury cup must be large enough and so centered that it will slide freely over the small valve tube without touching.

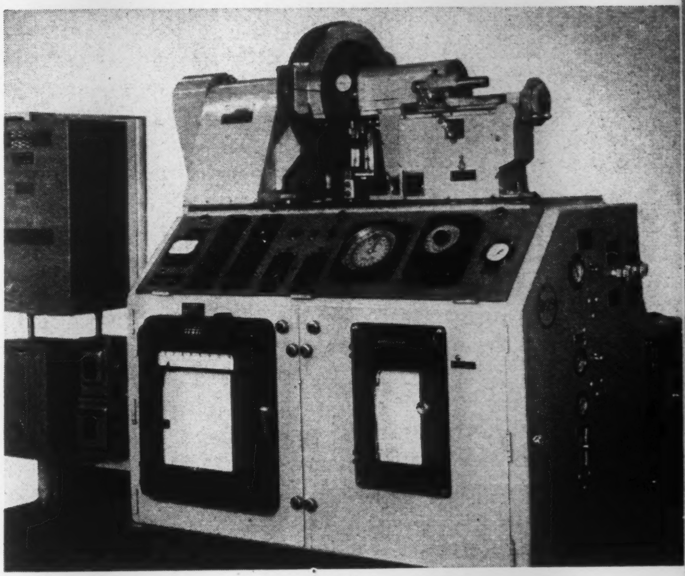


Fig. 1—View of complete machine showing control and recording equipment designed into the machine for accurate test results

FRICTION DYNAMOMETER

. . . with automatic torque control permits comparative production testing of friction materials for close control of major characteristics

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BRAKE lining test machines have been constructed generally for the purpose of testing individual friction facings or combinations against a particular brake drum. Such tests utilize standard brake assemblies set up to measure the effectiveness of lining combinations when braking a rotating mass from a known velocity in a measured time interval. The aim of such testing is to correlate the results so obtained with actual road performance after consideration of such factors as: (1) Moment of inertia of dynamometer load vs. vehicle weight; (2) dynamometer flywheel speed vs. vehicle speed; (3) traction between vehicle tires and road surfaces; and (4) distribution of braking effort in the particular vehicle.

Test results from inertia type dynamometers may thus be studied to improve design and application of brakes in particular vehicles. These results reveal much that is important in lining performance—friction levels, fade, wear, etc. Where the primary aim is lining development, there is a definite place for a test machine, *Fig.* 1, from a laboratory viewpoint. Of course, such development need not be completely divorced from its later application to vehicular use, and in the case of this machine, correlation of data has been made by comparative analysis of tests on linings which have already been accepted by the automotive industry.

Particular advantage in the use of a friction testing machine is in the rapid evaluation of laboratory formulation changes, in the analysis of standard formulas processed with new equipment, and in the evaluation of processing changes, all of which tests may be compared with friction materials processed with accepted methods and materials. All such development work may proceed with the idea of improving such lining characteristics as fade, durability, etc. Thus the immediate aim of test work on this

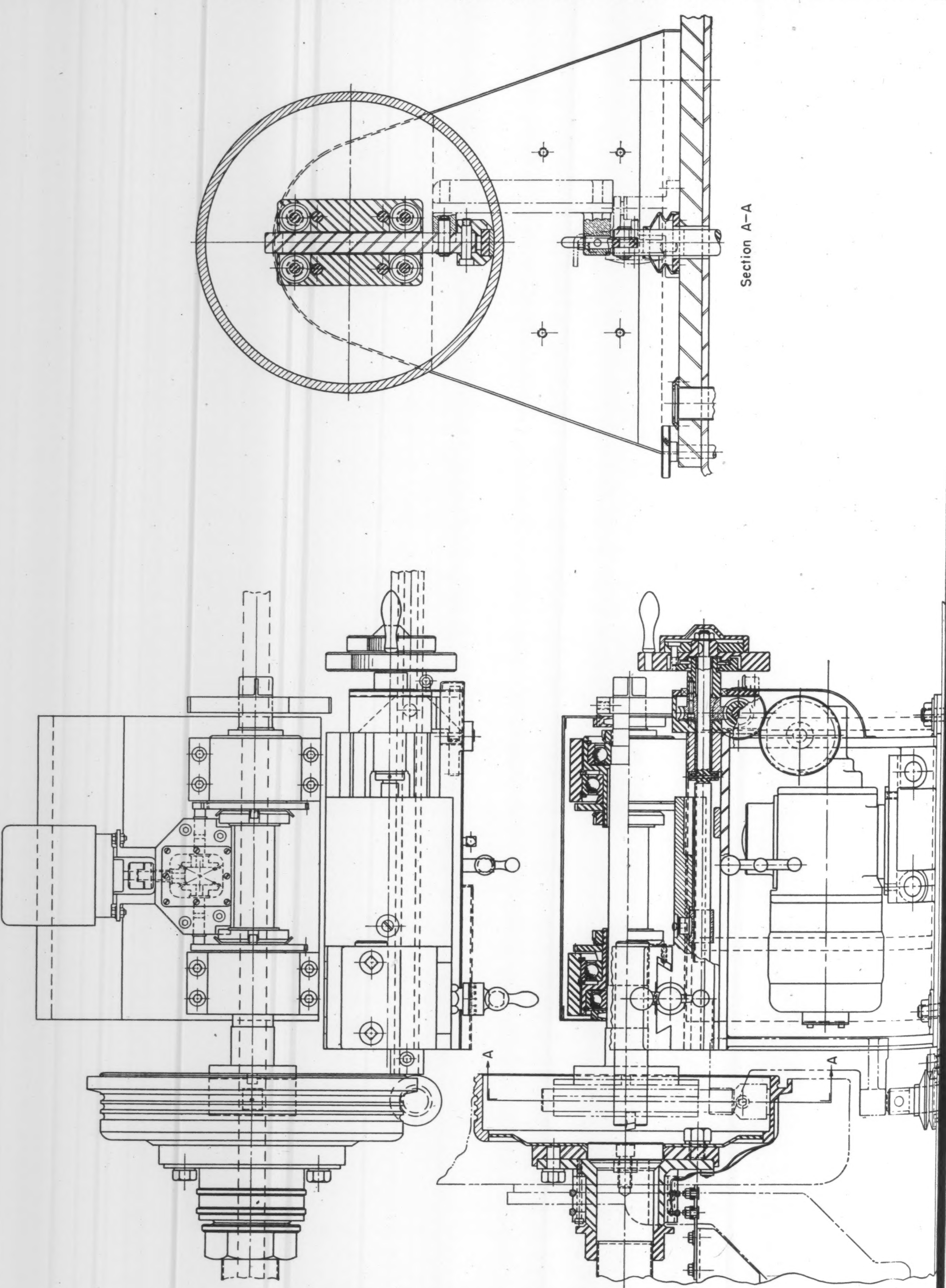


Fig. 2—Cross section drawing showing sample roller slide and contrarotating bearing arrangement of shaft for low friction

machine is the rapid evaluation of basic changes in lining processing or formulation with all outside factors being controlled.

Design Requirements: After a thorough analysis of these aims, plans called for the design of a machine which could evaluate the properties of all types of friction materials, regardless of size, consistency, arc, etc. Such a design was centered around the use of a sample one square inch in cross-section which could readily be placed in a fixture for test. In this manner samples for friction test could be cut from brake blocks, truck segments, or passenger car linings.

Basically the design aim was to have attached direct to a load mechanism a sample fixture which would apply the friction material to a standard 11-inch diameter automotive brake drum mounted on a constant-speed input shaft. Friction resulting from contact between the rotating drum and sample would rotate the sample fixture, in turn rotating the output shaft and working a pivoted arm against a force measuring device. Refinements were to be included in the design of the machine for such reasons as (1) maintenance of proper drum finish, (2) thorough temperature control and measurement, (3) calibration of torque measurement, and (4) maintenance of a high degree of accuracy under operating conditions. In addition, torque control mechanisms were added to the machine after the initial installation.

Motor-Clutch Drive and Controls: A 10-horsepower motor with an eddy-current clutch (maximum speed 1000 rpm) was employed for the mechanical power source of the dynamometer. The eddy-current clutch maintains constant drum speeds as set by rheostat controls mounted on the dynamometer panel. Two motor rheostats enable the operator to set up two different speed settings to facilitate changes in drum speed during tests without rheostat adjustment.

Power is transmitted to the input shaft by a belt drive between two pulleys with a 1 to 1 speed ratio. The drive consists of four steel-cable reinforced B-section belts.

Input Shaft and Drum Mounting: The input shaft has a pulley at the driving end and an 11-inch diameter automotive type brake drum mounted on the driven end. This shaft is supported by two ball-bearing pillow blocks mounted on a welded-steel base. A generator mounted on the pulley end of the input shaft measures drum speed by means of a speed indicator on the control panel.

Sample Fixture and Load Beam: In preparation for test, a friction material sample is cut from a selected test segment and finished to one square inch surface area, and then ground or sanded to 11-inch outside diameter for full surface contact with the drum. The sample is held during test with jaws extending from the side of the fixture. During sample preparation the fixture is detached from the square torque arm to facilitate fitting the friction material sample. The sample holder, with a sample mounted in the jaws, is attached to the square input torque arm which rides up and down guided by four ball bearings seated in a rectangular guide, *Fig.* 2. This guide is keyed to the torque output shaft to transmit a measure of the torque created by friction between the sample and the rotating brake drum to the measuring device.

The load beam is attached to the sample fixture by a series of linkages which directly transmit loading on the beam to the fixture. This load beam is pivoted to give a loading ratio of 5 to 1 for the weights added at the end of the input arm. The short end of the beam is held horizontal by a steel tape fastened to a leveling spool at the bottom of the machine. This

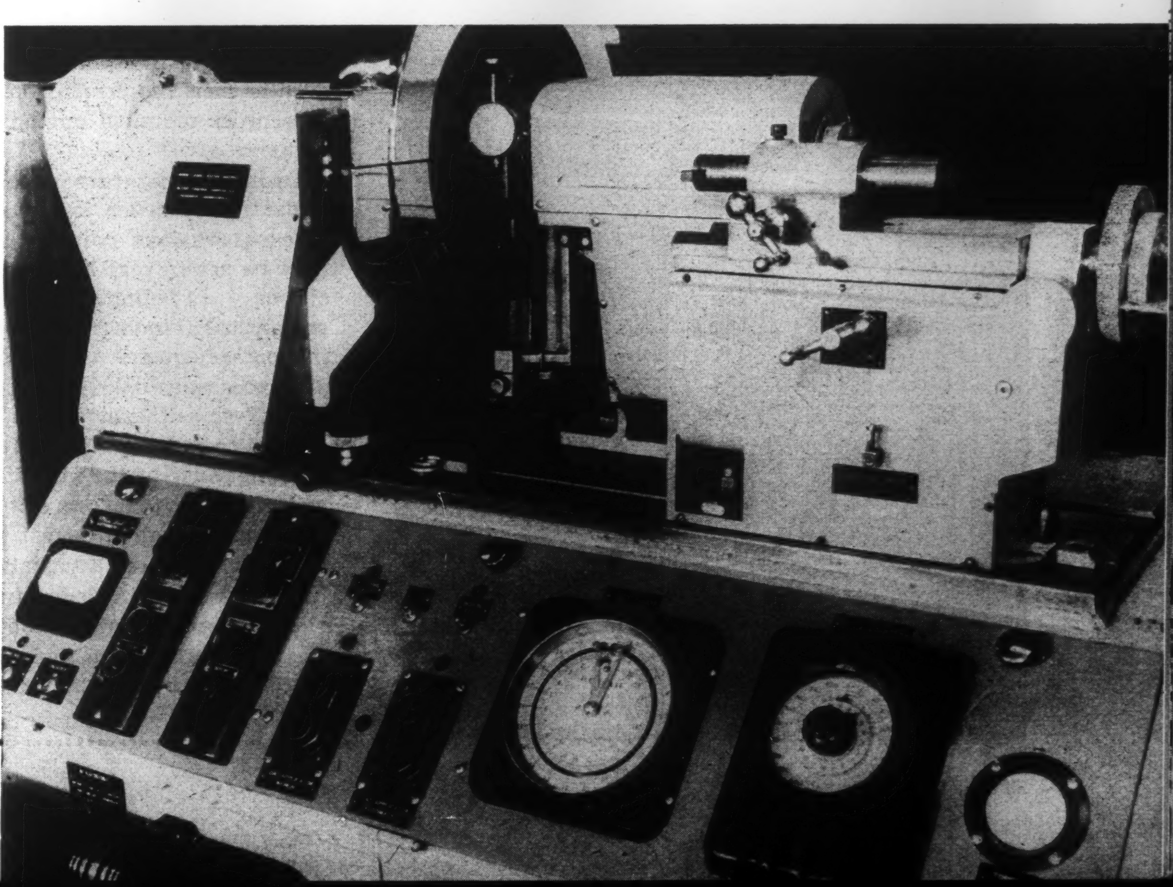


Fig. 3—Close-up of machine showing drum turning head in retracted position

spool is attached to a worm gear controlled by a torque rod accessible at the top of the machine to permit leveling the torque arm when different loads are used. A spirit level on the loading beam is used during this procedure.

Air-draulic Load Beam Support with Controls: Application and release of the load is controlled by an air-hydraulic cylinder ram which supports the load beam. This cylinder, in turn, operates under either automatic or manual control, depending on the operator's selection. The cylinder itself is hydraulically self-contained and is actuated by externally supplied compressed air. A valve in the hydraulic system controls the rate of travel of the support, with travel rate for different loads controlled by an air pressure regulator pre-set by the operator.

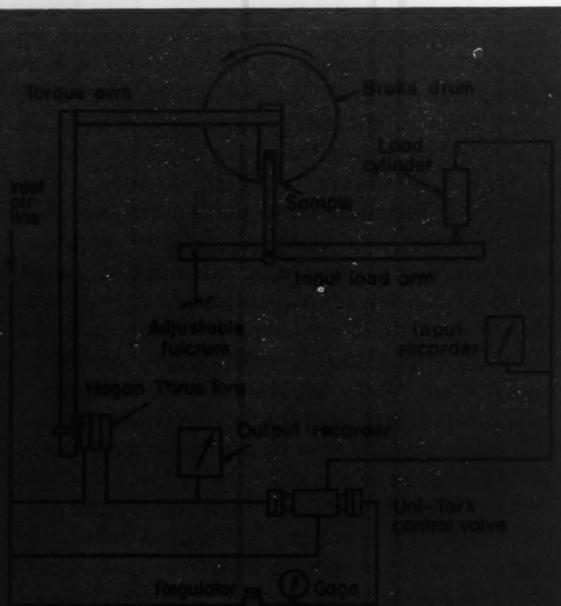


Fig. 4 — Schematic diagram of dynamometer torque control arrangement

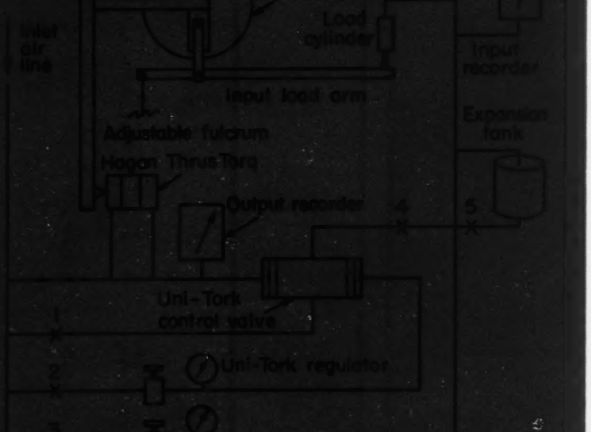


Fig. 5—Schematic diagram of torque control circuit as revised to provide both manual and automatic control

In automatic control, the supporting hydraulic cylinder responds to air pressure admitted through a solenoid valve controlled by a cycle timer and a cycle counter. Under manual control, the operator simply by-passes the counter and timer and directly actuates the solenoid which controls air passage to the air-hydraulic cylinder. The timer sets up "on" and "off" periods of the cycle. A minimum complete cycle time of twenty seconds and a maximum of twenty minutes "on" and twenty minutes "off" is possible. In conjunction with the timer, the counter controls the number of complete cycles.

Output Shaft and Torque Arm: The torque shaft itself is supported near both ends by contrarotating ball bearings driven by a small motor through bevel gearing, *Fig.* 2. This type bearing support was designed to cancel out friction and to prevent brinelling of the races.

Keyed directly to the torque shaft is a primary torque arm five inches long. This arm is attached to the secondary torque arm—the arm which signals the torque measuring diaphragm—with an adjustable connecting linkage locked to prevent change in distance between centers of both arms. This secondary torque arm is mounted on a low-friction bearing above the surface plate. The use of both a primary and secondary torque arm was dictated by space limitations.

The torque arm acts directly on the loading side of a Hagan ThrusTorq unit, forcing its measure of torque against a diaphragm; this action in tending to move the diaphragm opens a poppet valve which admits air from the inlet air line. This air pressure increases until it just balances the mechanical force transmitted by the torque arm at which point the diaphragm is in equilibrium. This balancing air pressure is then the measure of torque and is signaled to a recorder mounted on the front of the machine.

Drum Temperature Arrangement and Heater Controls: A recorder is used for registering temperatures at various points during test. Thermocouples may be set to read temperatures at the following positions: (1) Imbedded in friction sample approximately 0.050-inch from surface; (2) with button riding on rotating drum surface; and (3) in drum rim approximately 0.050-inch from friction surface.

Use of a thermocouple imbedded in the friction sample to measure lining temperature proved of little value because of the insulating properties of the lining and the fact that this insulating barrier continually changes throughout a test while the lining is wearing. Tests have shown a variation of not more than 10 F in correlation of drum temperature with a couple riding on the drum vs. one imbedded in the drum. In all cases the surface thermocouple ran slightly higher in temperature and a little more erratic. For this reason tests on the machine have been standardized with use of the thermocouple imbedded in the drum, and other positions are used for special tests only.

Head of the drum thermocouple is a soldered junction securely positioned in a drilled hole approximately 0.050-inch from the drum surface. The hole is drilled from the outside surface in the center-line of the sample's path across the surface, and the thermocouple is insulated with asbestos fibre. Leads run to the hub plate where the terminals are attached and thence through the input shaft to iron-constantan slip rings. Spring-loaded contact brushes (one iron, the other constantan) pick up the signal and transmit it to the recorder. All leads, connectors, rings, and brushes are iron-constantan to avoid the possible introduction of secondary thermocouples caused by temperature differentials across connecting points.

An additional feature of this machine is the built-in heater strips surrounding the drum and enclosed by an insulated shroud. The heating elements are four Chromolax strips with a combined capacity of 3 kw. Any setting up to 750 F may be maintained. A small circulating fan controls the air flow through the shroud for both heating and cooling.

Drum Turning Attachment: To insure comparable test results, the drum surface must be uniform from one test to the next. For this reason, a drum turning attachment is provided to correct radial runout and clean up marking or heat-checking of the drum prior to test runs.

A complete boring mechanism is provided which may readily be moved into place. This mechanism is clamped to the table of the dynamometer, *Fig.* 3. The depth of cut is set up with a lathe cross-feed handle on the front of the mechanism. The feed of the cutting tool may be controlled manually or by motor drive. A toggle controls direction of feed of the tool, and the speed control of the boring feed motor is mounted on the front panel.

Torque Controls: After the dynamometer had been in operation for several months, the necessity for a torque control was far more obvious than when the machine was in the design stage. The first torque control unit was added approximately six months after installation of the machine. This control unit was automatic. Approximately two years later a manual torque control unit was installed.

Basic features of the automatic torque control may be explained with reference to the schematic drawing shown in *Fig.* 4. As in the original design the rotation of the brake drum in contact with the friction sample forces the sample to rotate its fixture in a counterclockwise direction and forces the torque arm against the diaphragm measuring device, force of the arm being the measure of friction.

As air pressure builds up in the measuring device of the new design, it also signals the double diaphragm type torque control of the change in torque. This pressure builds up on the diaphragm of the control valve and moves the valve plunger against the other diaphragm which has a pre-set pressure—the pressure equivalent to the desired torque. Motion of the valve permits entry of air pressure to load the air cylinder which works the input load arm, forcing the sample against the drum and returning the torque to its pre-set value. Similarly, it can exhaust air from the air cylinder when the torque signals a buildup in friction.

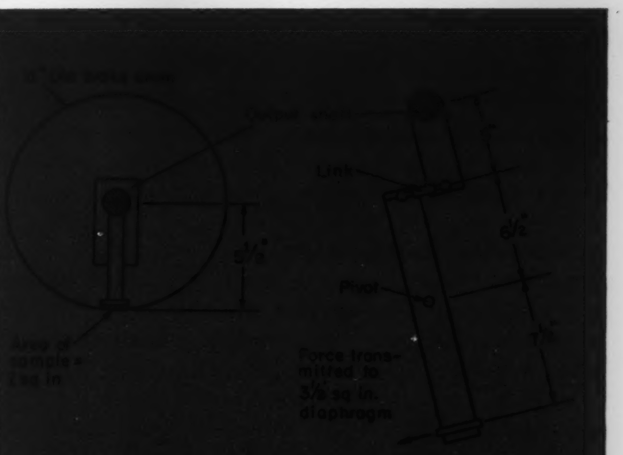


Fig. 6—Basic machine linkage measurements for use in computing friction values from recorded air pressure

A pressure recorder charts the actual load on the sample by measuring the air pressure in the cylinder. This air pressure multiplied by the leverage of the input load arm is the load on the sample. Dead weight of the sample fixture and load arm is taken into account with a null reading of 20 pounds on the input pressure recorder.

A manual torque control was added to the machine to enable running short routine applications. This was not feasible with the automatic torque control which had pulsations—the alternate admission and exhaust of air—and which did not permit ready observation of the input during a short stop (the observer would not know which part of the input stroke to use as his input value). Thus, in order to set up short applications with a steady input, which could be varied to hold the desired torque, a pressure regulator was introduced into an auxiliary control system. This regulator is operated manually to control the air pressure to the load cylinder at the end of the load beam. Thus manual torque control applies steady input to the sample which can be used on very short routine applications. A schematic of this manual torque control is shown in *Fig.* 5 as part of the overall control system.

The method of operation is simple. When it is desired to use the manual torque control setup, the operator merely shuts off the valves to the automatic system and opens the valves to the manual torque control unit. Valves 1, 2, 4, and 5 are turned off, and valve 3 is opened. Check valve 6 permits flow from the manual regulator, but stops air from backing up when the automatic control is in use. Then the operator starts the cycle, observes the output recorder, and changes the regulator setting to maintain the output at the desired level. The machine cycle controls may be set for short routine stops, while the torque is being maintained by the operator.

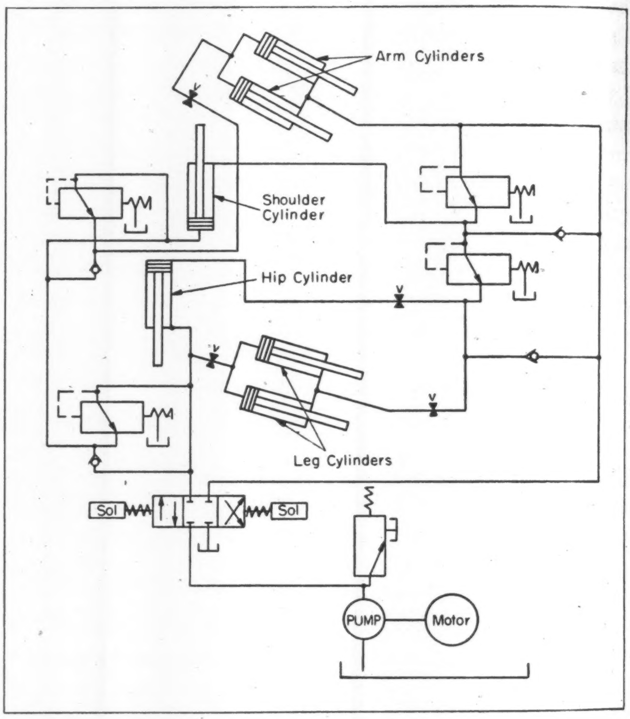
Calibration and Computations: A check on the accuracy of the torque measuring system is made with a clamped lever arm attached to the output shaft at that point where it works the arm to the Thrus-Torq measuring device. By attaching calibrated weights to this arm, the equivalent measure of torque may be read on the graphic recorder. Any slight failure of correlation may be compensated by resetting the zero point on the recorder.

To determine the coefficient of friction from results on the graphic recorders, it was necessary to make the following computations with the fixed data shown in *Fig.* 6: Torque = Force × Radius or $T = 5.5\mu L$ and $\mu = T/5.5L$ where T = torque, lb-in.; F = force, lb; L = load, lb. To determine coefficient of friction μ directly from air pressure, P: torque at both ends of the output shaft is considered equal (no bearing loss) and, therefore, the force at the link $= (5.5\mu L)/5$ and the force at diaphragm $= (6.5/7.5)(5.5\mu L)/5$. Also: Force at diaphragm $= P \times$ area of diaphragm or $3.5P$ and therefore, $3.5P = \mu L(6.5 \times 5.5/7.5 \times 5)$. Thus, coefficient $\mu = 3.67P/L$.

Hydraulic "Mechanical Man"

HYDRAULIC cylinders, valves and pumps enable "Luigi", a "hydraulic man" developed as a display by Rivett Lathe & Grinder Inc., to move his arms, legs and feet, stand up, and sit down. Displayed at the ASTE Show, Luigi had gages for eyes and a switch for a nose. His stomach was transparent to show valve operation.

Luigi's intricate circulatory system consisted of a set of hydraulic cylinders into which oil flow was directed by a series of sequenced valves and a double-solenoid spring-return valve from a positive-displacement pump. The sequence of operations involved movement of his knees, hips, shoulders, arms and back. A cutoff valve returned oil to the main valve, releasing pistons in each of the main cylinders.

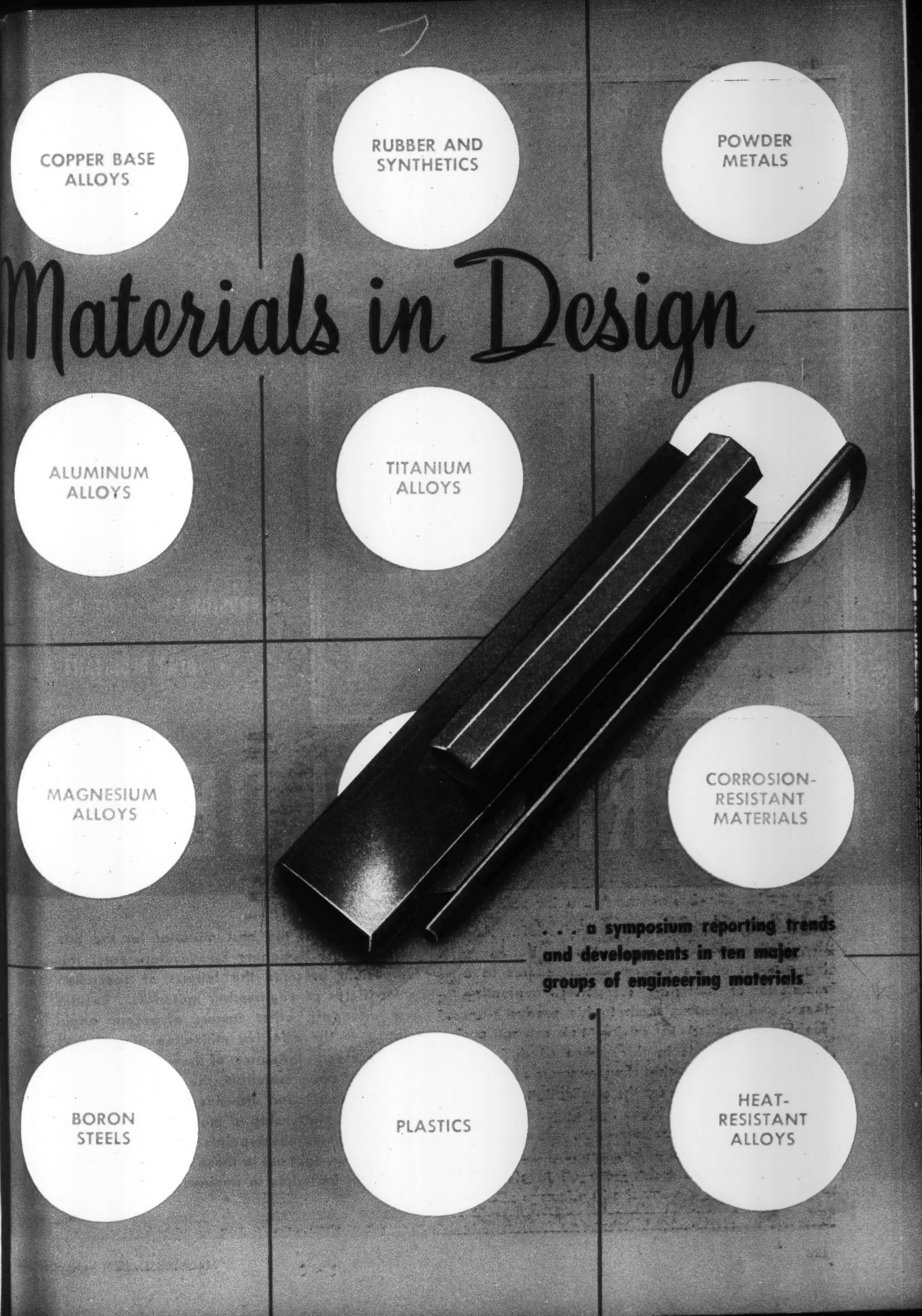


"Only by increasing productivity per worker by 30 to 35 per cent during the next ten years will it be possible to maintain the greater population at a standard of living equal to or better than today's level. The only answer is to provide every American worker with more effective tools and methods so that we can produce and distribute, in vastly increased volume, goods and services for the American people."—JOHN L. COLLYER, *president, The B. F. Goodrich Co.*

"Although at the head of a nice little firm I founded with a few thousand dollars and a lot of ambition twenty odd years ago, I still am fundamentally a mechanic and designer of machinery. Perhaps I will be called a dreamer, but I have found most worthwhile accomplishments have to be dreamed about a while before progress can be made. People have said to me, 'You never did build a failure, did you?' Brother, they don't know the half of it! But the reason they think so is that if a machine doesn't work I always cut it up and throw it away, right quick, before anybody sees it."—R. G. LETOURNEAU, *president, R. G. LeTourneau Inc.*

7

Materials in Design


COPPER BASE ALLOYS
RUBBER AND SYNTHETICS
POWDER METALS
ALUMINUM ALLOYS
TITANIUM ALLOYS
MAGNESIUM ALLOYS
CORROSION-RESISTANT MATERIALS
BORON STEELS
PLASTICS
HEAT-RESISTANT ALLOYS

. . . a symposium reporting trends and developments in ten major groups of engineering materials

COPPER-BASE ALLOYS

TITANIUM ALLOYS

BORON STEELS

RUBBER AND SYNTHETICS

MAGNESIUM ALLOYS

POWDER METALS

PLASTICS

ALUMINUM ALLOYS

CORROSION-RESISTANT MATERIALS

HEAT-RESISTANT ALLOYS

MATERIALS IN DESIGN

Engineering materials are never static. And therein lies a designer's opportunity. But keeping abreast of the diverse developments in a multitude of materials categories, evaluating them, and adapting them to his product—are problems entailed in seizing the advantages offered. Yet, it is in this phase of design—materials selection—that developments of others are often tailor-made for the application at hand or are the sources of ideas that engender product improvement. Performance, producibility, cost, appearance—the fundamental issues of engineering design today—are all involved in the selection of the best material for the job. To help post designers on developments, this symposium presents the reports of specialists in ten fields of engineering materials. Besides new materials, other factors of recent origin relating to the effective utilization of materials are discussed. Influence of new methods and equipment upon materials, the design approach and materials found effective for critical service conditions, relationship of materials to manufacturing processes—such points of current or future value are brought out in these short authoritative reports on materials in engineering design.

COPPER-BASE ALLOYS

D. K. Crampton

Dir. of Research, Chase Brass & Copper Co., recounts some of the recent metallurgical and processing advances in this broad field. A director of ASTM and active in other technical societies, Dr. Crampton has contributed a number of papers on various aspects of this field and holds numerous patents relating to the technology of copper-base alloys.

SIGNIFICANT developments in any field are likely to be the result of relatively slow trends culminating in certain specific useful features. This is certainly the situation in the field of copper and copper alloys. The topics discussed in some detail in this article have perhaps all been mentioned in the literature or in producers' catalogs but probably not brought together in a way that gives the machine designer a comprehensive guide. It is hoped this review will serve that purpose.

Strength Criteria: A subject of primary importance to machine designers is that of permissible stresses in various engineering materals used under different situations. Even in well-established metal producing industries, there is frequently a lack of complete data for different conditions of service, especially those involving elevated temperatures. In recent years the nonferrous subgroup of the ASTM Boiler Code Committee has been reviewing existing information on properties of copper-base alloys over a range of temperature in compiling data to be published in the Unfired Pressure Vessel Code. Such data may be taken as a guide for many other applications particularly where temperatures substantially in excess of room temperatures are met. The data cover many of the more commonly used wrought copper-base alloys and provide a good basis for estimating reasonable stresses for similar or intermediate alloys.

In setting up these maximum allowable design stresses, the criterion was the lowest of the following:

1. One-quarter of tensile strength as determined in the short-time test
2. Two-thirds of yield strength, in turn defined as the stress corresponding to ½ per cent extension under load in the short time test
3. 100 per cent of creep strength, which is taken as the stress for secondary creep rate of 0.01 per cent per 1,000 hours
4. Four-fifths of the stress (by extrapolation) to produce rupture at 100,000 hours.

Cupro-Nickel: One of the interesting wrought alloy developments in recent years is 10 per cent cupro-

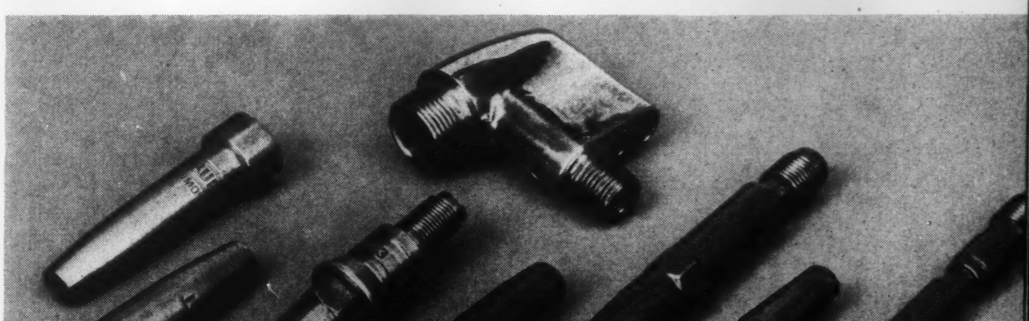


Fig. 1—Gas welding and cutting tips showing suitability of tellurium copper for hot forming, cold swaging, and difficult machining and drilling operations. Parts must exhibit high thermal conductivity also

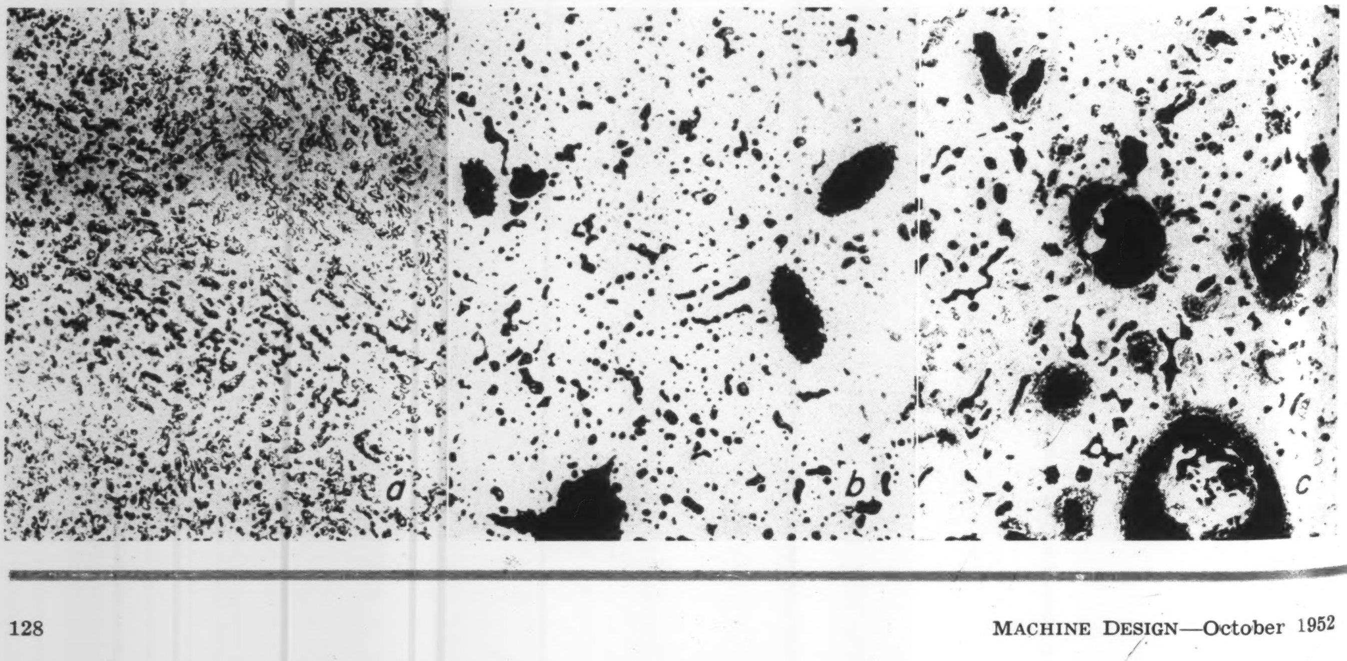
nickel containing iron. It has been amply demonstrated that the impingement or erosion-corrosion resistance of the 90 copper—10 nickel alloy could be substantially improved by the addition of iron from about ¾ to about 2 per cent. Indeed this corrosion performance appears to approach that of 30 per cent cupro-nickel so long considered the optimum copper-base alloy for heat exchangers operating at rather high temperatures and condensers using high velocity cooling waters. Also the high-temperature strength properties are substantially better than those of copper and brasses although not equal to those of the 30 per cent cupro-nickel.

The 10 per cent cupro-nickel also has properties which should make it widely applicable for use in bolts, rivets, screws and similar fasteners. Even in the very hard-drawn condition it is malleable enough to be readily cold headed, roll threaded, bent or otherwise formed as might be necessary. Its corrosion resistance indicates it could properly be used in service where many other alloys would not be adequate. Finally, the maintenance of properties up to moderately elevated temperatures and its extremely high resistance to stress cracking are attributes not to be overlooked.

Strip Brasses: Over a period of many years, the ordinary strip brasses used for a great variety of fabricated products have been available in a wide range of temper. As annealed to finish, grain sizes have usually been anywhere from about 0.015-mm to perhaps 0.070-mm for most applications. Strip with smaller grain size is of course harder and stiffer whereas the metal with larger grain size would when formed show a more or less objectionable pebbly or orange peel surface. There was formerly a tacit assumption that it was neither practical nor desirable to produce such material with grain sizes less than about 0.015-mm. In the last few years there has been an interesting and valuable development in this direction. Annealed strip in the thinner gages is available with grain sizes distinctly less than 0.005-mm and ranging down to 0.001-mm. This material has strength and stiffness comparable to brass rolled with 10 to 20 per cent reduction after a more normal anneal, and at the same time, much greater ductility than would result from such quarter or half-hard strip. The outstanding quality, however, is an exceedingly fine surface texture which even after a substantial forming or drawing is sufficiently smooth so that only little subsequent work must be applied to bring out a lustrous surface.

Selenium and Tellurium Additions: In the last decade increased use has been made of the elements selenium and tellurium as addition elements in copper-base alloys to supplant lead as a means of promoting ease of cutting or machinability, *Fig.* 1. In particular, two tellurium-bearing alloys are produced in rod form suitable for fabrication on screw machines into a multiplicity of parts. These alloys are also adapted to fabrication by forging where such a method of producing irregular-shaped parts has advantages over screw machine processing. Tellurium copper containing approximately 99.5 per cent copper and 0.5 per cent tellurium has a machinability rating of 90 per cent of that of free-cutting brass, and an electrical conductivity approximately 90 per cent of that of pure copper. Depending on size and temper, it exhibits tensile strengths from about 42,000 psi to about 55,000 psi with elongation in 2 inches from approximately 35 per cent to 8 per cent.

Fig. 2—Photomicrographs of 75 per cent copper—5 tin—20 lead alloy at 100X magnification, produced by three methods: *a*- continuous cast rod, *b*- conventional permanent mold castings, and *c*- foundry sand castings. Continuous casting procedure for rod and other sections gives fine, uniform structure



The other tellurium alloy is age-hardenable, containing 0.5 per cent tellurium but with approximately 1 per cent nickel and 0.2 per cent phosphorus to give the age-hardening characteristics. Depending on size and temper, tensile strengths of about 65,000 to about 95,000 psi with elongations from about 40 per cent to 5 per cent are obtainable. Due to the presence of the nickel and phosphorus, the electrical conductivity is about 50 per cent of that of pure copper and is relatively little affected by the temper of the material. This value is unusually high for a material of the strength property indicated. The alloy finds wide application in forging and screw machine parts for structural uses requiring the combination of high strength, hardenability, corrosion resistance, high electrical and thermal conductivity and easy machining.

Bronzes: The tin bronzes with and without lead have come into increasing use due to new developments in processing. The more important one of these is the application of continuous casting procedures to rod and tubular sections. In that procedure the material is melted and cast under a nitrogen atmosphere and is rapidly and continuously frozen from the bottom upwards so that the material is unusually clean, sound and of very much finer and more uniform structure than is obtained by other casting procedures, *Fig.* 2. Practically all of the copper-tin and copper-tin-lead alloys are amenable to this treatment. Those of such high lead content that they can not be economically worked, are available in long lengths as-cast, and have a structure particularly well suited for use in bearings, bushings, valve guides and small gears.

The straight tin bronzes, of which the 5 per cent and 8 per cent are most commonly used, and the alloy containing 88 copper, 4 tin, 4 lead, 4 zinc are also well adapted to subsequent cold processing. After such working with suitable intermediate annealing, these materials exhibit structures and physical properties superior to the same materials starting from conventional castings. In particular the 88-4-4-4 alloy in the wrought conditon offers greater possibilities for both sleeve and thrust bearings, bushings, gears, pinions, washers, valve parts, etc. One interesting application of the alloy is for drawn pinion stock where the gear teeth are actually formed by cold drawing and the individual pinions cut therefrom. This combination of sufficient ductility for severe drawing and high machinability is enhanced by the casting procedure.

Methods: A development which at first glance might seem far removed from the field of machine design is the application of spectroscopy and particularly the newer direct-reading spectrochemical techniques to analytical control of wrought copper alloys. The importance lies in the resulting better knowledge and uniformity of the materials and therefore of their properties. Quite obviously such improved uniformity is of real significance in many machine components .

A development of significance to machine designers and fabricators is the increasing application of quality

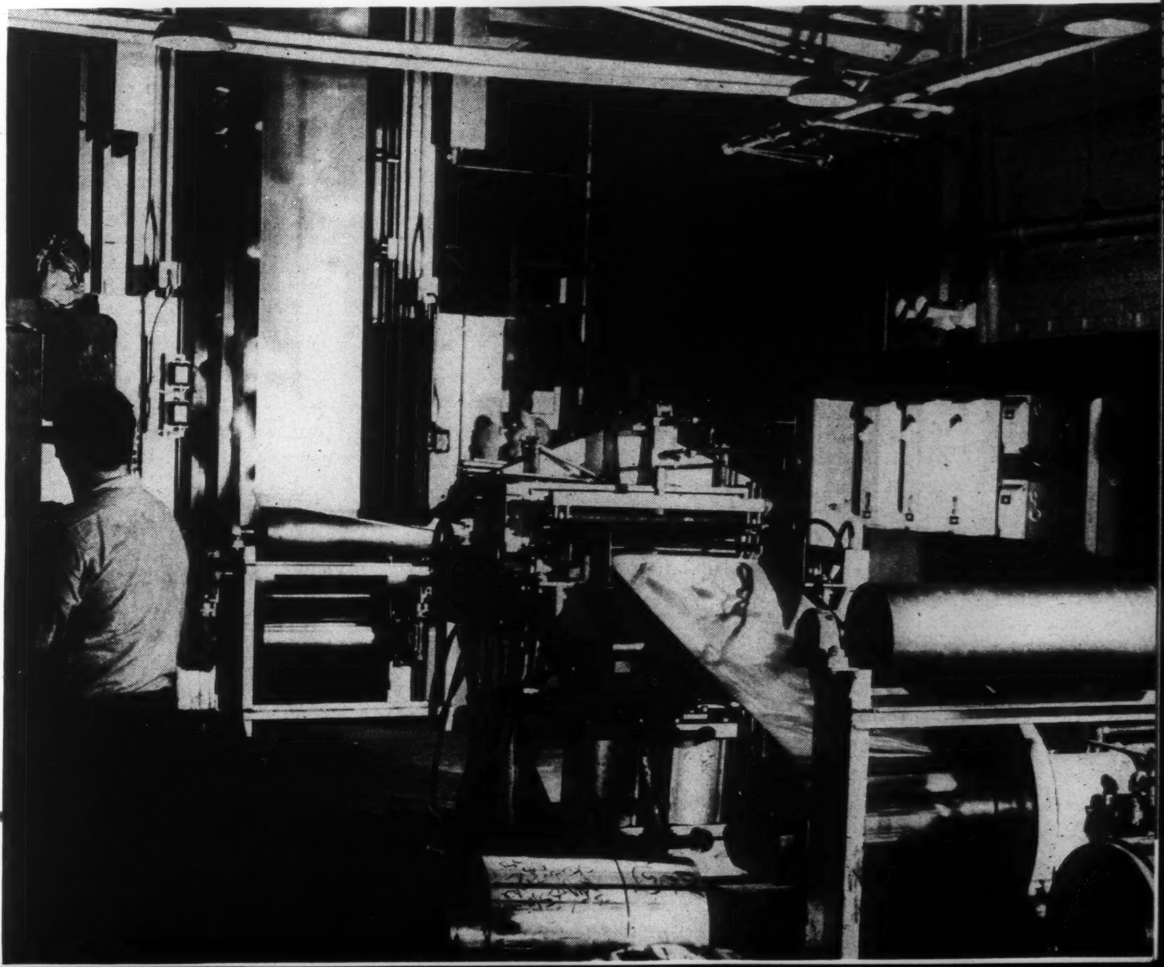


Fig. 3 — Feed end of continuous strip annealer which produces high uniformity, clean-annealed brass

control sampling procedures to some mill products. Such an approach to the inspection and testing problem gives overall better control and greater certainty of good quality and meeting of special requirements.

The annealing furnaces, atmospheres and handling techniques in modern brass mills have been greatly improved in recent times. For a while the belief was generally held that bright annealing of brasses to produce a very uniform and completely oxide-free surface would be a valuable aid to fabricators. It was found, however, that although the cleanliness and uniformity were desirable in themselves, such bright annealed surfaces were not readily wet by lubricants used in drawing and forming operations so that serious scratching or breakage resulted. The more recent techniques are to use so-called clean annealing produced by moderately reducing furnace atmospheres, *Fig.* 3, and then to flash pickle off the resulting light oxide. The final product has a pleasing and uniform appearance, is readily wetted by lubricants and is well adapted to severe forming and drawing operations.

The increasing weight of single rolls of strip is of real value in fabrication for it results in greater efficiency in cutting-up operations. This development sometimes leads to a somewhat different aspect of machine design than ordinarily considered, namely, the devising of fixtures for holding and devices for feeding such long rolls of strip into production presses.

TITANIUM ALLOYS

Herbert A. Jahnle **Warren S. Hazelton**

Metallurgical Section, Aviation Gas Turbine Engineering, Westinghouse Electric Corp., give an objective view of this promising material. Drawing from experience and observation in gas turbine engineering, the authors sum up the plus and minus features of titanium and its alloys.

TITANIUM now finds itself the object of concentrated development. After acclaims of "wonder metal," "answer to the engineer's prayer," and other equally pretentious descriptions, industry is now taking a more realistic approach to the application of the metal. There are many questions to be answered, and they are being investigated in basic research in different fields.

Since the raw material must be homogeneous and have consistent properties, the basic problems are metallurgical. The homogeneity and consistency of heats improve with melting experience. The development of alloys to obtain a wide range of mechanical properties is a long and often complicated process.

A short discussion of the physical characteristics of titanium will present a brief picture of the development of its various alloys. Metallurgically, titanium is a metallic element having a hexagonal close packed structure, alpha, at room temperature. At 1625 F this structure transforms to a body-centered cubic structure, beta. Impurities and alloying elements either raise or lower this transformation temperature. These elements also tend to stabilize or strengthen one of the phases which permits the retention of that particular phase at operating temperatures. Thus an element that raises the transformation temperature and also strengthens the alpha phase will permit the use of the alloy at a higher temperature than the commercially pure material. Alloys that have both the alpha and beta phases present at room temperature have properties that are controlled by hot and cold working and heat treatment. Thus three types of titanium-rich alloys are possible, namely, all alpha, alpha plus beta, and all beta.

The only alloys on the market at the present time are of the two-phase type. These alloys have good room temperature tensile properties that fall off rapidly above 750 F. A wide range of tensile properties is obtainable, starting with 55,000 psi for commercially pure titanium, to 175,000 psi for one of the alloy grades. The high-strength alloys have good creep strengths up to 700 F and have 100 million cycle endurance strengths at 500 F ranging from 45,000 to approximately 65,000 psi.

Experimental heats of all-alpha and all-beta alloys have been made by Rem-Cru Inc. The strengths of these alloys, plotted as their strength-weight ratios, are compared to other titanium alloys as a function of temperature in *Fig.* 4. They appear to have far better high-temperature properties than the two-phase alloys.

In general, the design problems with titanium are no different from those with any other metal. It must be realized that although titanium alloys have high tensile strengths, they are in the light metals class and have characteristics of light metals such as a low modulus of elasticity. Consider the design of a compressor rotating wheel for a gas turbine engine consisting of a steel disk and steel blades. Titanium alloys could not be substituted for the steel in the disk without a change in design. The natural frequency of the titanium disk would be lowered to a point where it could be in resonance with the engine running speed. However, if titanium blades were used with the titanium disk and both were designed the same as the similar steel parts, the frequency of the resulting part would be the same as the frequency for the steel assembly. This truth holds, of course, because the frequency of any part is proportional to the geometry, modulus of elasticity, and density of the material. The effective product of modulus and density of steel is the same for titanium.

As another example in jet engine work, as well as in other applications, a property that must be considered in design is damping capacity. Often a material is used mainly because it has the ability to absorb energy, thereby limiting the maximum vibratory stresses set up in the part when operated at resonant conditions. In jet engines the compressor blades are usually 12 per cent chromium stainless steel, principally because of the high damping capacity of this material. Excessive aerodynamically induced vibrations are damped out by the combination of material damping and frictional damping at the blade-disk fastening. When titanium alloys are considered for compressor blades, the lower damping of the material must be offset by an increase in the mechanical root damping to prevent stress amplifications at resonance from becoming so great that premature fatigue failures result.

Titanium has a high notch sensitivity, and parts must have a clean, smooth surface. The endurance strengths of blades tested at Westinghouse having scratched surfaces were much lower than blades having polished surfaces.

The high strength-weight ratio of titanium alloys suggests their use in such aircraft parts as bearing housings or splined shafts. The galling tendency of titanium, however, limits its use in this type of application. Although titanium forms very hard carbides, oxides, or nitrides, there has not been much success in consistently obtaining a hard bearing surface.

To date there is no known practical method of casting titanium into shapes other than ingots. The raw material is received either as rough forgings, bar stock, or plate and sheet. The processes used in producing these various forms break up the as-cast structure and yield reasonable combinations of strength and ductility.

Large titanium forgings usually are not very uniform in properties; tensile properties vary at different locations in the forging. Metallographic studies show different ratios of alpha to beta, and different grain sizes. Many of these inconsistencies can be traced to segregations in the original ingot, while others can be traced to the forging operations. Small forgings that are made from bar stock can be more easily controlled.

A prime requisite for all forgings is to have clean furnaces. The oxidizing potential may be so high in some cases that the surface of the material will oxidize rapidly and produce enough heat to melt the remainder of the material. When parts having thin sections are forged there may be a complete penetration of oxygen or nitrogen which forms a brittle constituent in the finished forging. At Westinghouse, a lithium furnace is used in heating prior to the forging of small parts. The descaling process must be investigated thoroughly. There is some evidence that descaling with hydride or acid solutions may cause a reduction in impact strength, probably by a hydrogen embrittlement mechanism.

The best combination of properties can be obtained by forging in the alpha-beta region. This temperature range varies for the different alloys but in gen-

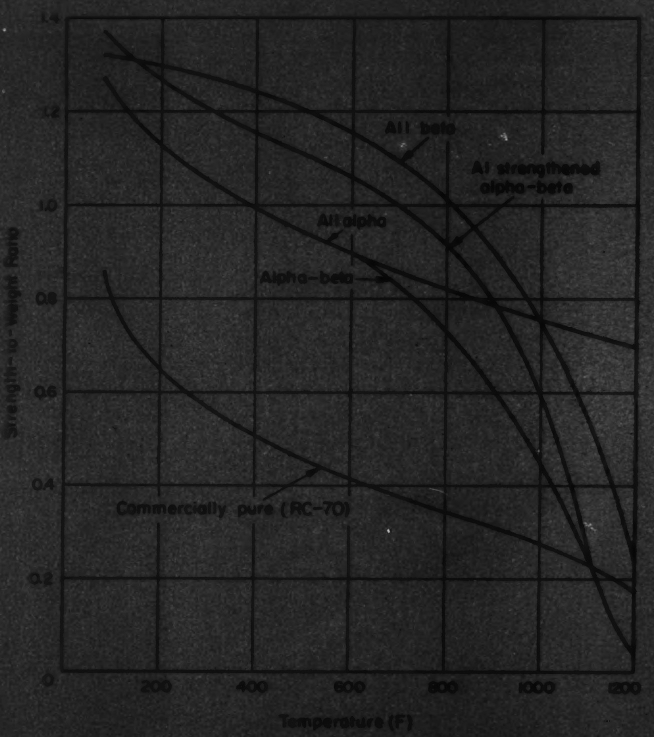


Fig. 4—Comparison of strength-weight ratio versus temperature for various titanium alloys. Data, courtesy Rem Cru Titanium Inc.

eral is between 1400 and 1850 F. At this temperature the metal does not flow readily and often intermediate dies are needed to get the desired finished shape. Heat treatments are usually necessary to stabilize the material and increase ductility of the forged part.

Titanium and its alloys have low coefficients of thermal expansion compared to the die steels. This may cause the forging to stick in the die. Lubricants can be used to alleviate much of this trouble. A colloidal suspension of graphite is often used as a lubricant, and even the oxide that is formed on the part by heating helps to prevent sticking.

Machining is necessary in most cases after forging, and has been one of the major problems in the development of titanium. Westinghouse investigators have spent considerable time on tool design, tool grades, and feeds and speeds. The material itself should be low in carbon, below 0.20 per cent, and the surface should be free of hard oxides or nitrides. Carbon is soluble in titanium to about 0.20 per cent, and above this content hard carbides appear in the material. The work must be held rigid and the tool must be sharp to allow a continuous positive cut and prohibit riding. A large force is necessary to remove the chip, and the result is a release of energy in the form of heat. This heat must be removed to prevent tool breakdown.

Investigators at Westinghouse feel that the removal of this heat is more important than lubrication and are attempting to use liquid carbon dioxide to do the job, *Fig.* 5. With carbon dioxide, the jets of gas must be directed exactly at the point of cutting. Excellent results have been obtained. With carbide-tip tools, surface speeds of 120 fpm in roughing and 180 fpm for finishing can be used. Speeds of 35 sfpm in roughing and 50 sfpm for finishing should be used when cutting with high-speed steel.

Broaches must be redesigned for titanium and its alloys. Again it is important to have a rigid setup to prohibit any movement of the work. Backup plates must be closely fitted. Single-pass broaches with a staggered tooth design give the best tool life and finish to the work. Some of the most important factors in broaching are designing the broach with carbide tips, providing for heavier cuts per tooth than are usually used on steel, and using optimum clearance angles.

Sheet metal has varied applications in many industries. These applications usually require a forming process with little or no machining needed. Alloyed titanium sheet materials have appeared on the market but they have not proved too successful, since they have directional properties, become brittle on heat treatment, and are difficult to form. Commercially pure sheet is widely used and has a multitude of applications. This sheet can be formed easily at temperatures between 50 and 1050 F. Cold forming methods must be closely controlled to obtain a finished part free from defects. The forming itself should be done at a slow strain rate. Impact forming does not allow the material to elongate or move sufficiently and cracking results. Generally larger radii are needed than for other sheet material. Because of the great amount of spring-back present, dies having a deeper

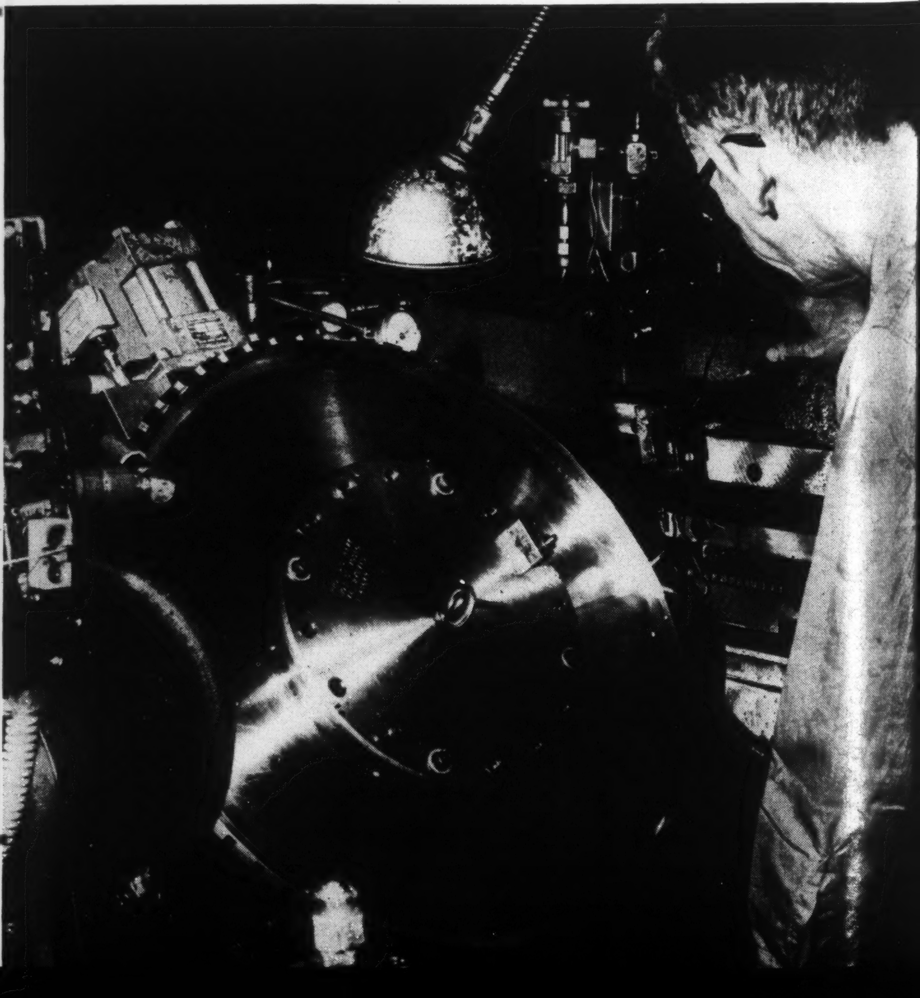


Fig. 5—Broaching a titanium alloy component with liquid carbon dioxide directed at the point of cutting to remove heat and prolong tool life

draw than the finished part are needed. In simple bend tests where there is no failure, the material may spring back as much as 25 degrees. Lubrication is desirable and dry-film lubricants such as graphite and molybdenum disulfide appear to do the best job. Intermittent anneals enable deeper draws and lower the force necessary to do the work.

Commercially pure sheet material can be welded by fusion methods with resulting good properties. Because of the affinity of titanium for gases, and the brittle phase they produce, inert atmospheres should be used. Parts can be welded in a large tank of inert gas. The process may be expensive for large parts and may require ingenuity to do the actual welding. Machine arc welding can be done using a normal inert gas shield backed up by an inert gas.

Spot and flash butt welds have high strength but often do not have sufficient bend ductility. The endurance strengths of spot welds are low and must be considered in the stress analysis of the finished part.

Because of the many unusual and advantageous properties of titanium and its alloys, there is a great interest in the two related subjects, availability and cost. Basically, the availability of titanium alloys should be good, because there are plentiful supplies of titanium ore in the world, and of particular strategic significance, in the United States. The main problems in making the metal available at a reasonable cost and in important quantities are associated with metallurgical and chemical difficulties.

The chemical properties of titanium, in particular its great affinity for oxygen, mean that rather complicated and expensive reduction methods must be used to win the metal from its ore. Although great strides have been made in the last five years, and many investigators are studying this problem, it appears thermodynamically improbable that any simple, cheap method of ore reduction will be found comparable to the iron blast furnace. However, this does not mean that titanium will always compare with semiprecious metals in cost.

As with any new metal, titanium is expensive. Bars and forgings have been selling for $10.00 per pound and up, and sheet costs about $20.00 per pound. Although these prices are expected to come down, how far and how soon, are difficult to predict. In any production process, one of the most important factors in cost is volume. The expected uses of titanium have resulted in great expansion in its production despite the high cost. This expansion cannot fail to cause reduction in price eventually, and probably will be felt in the near future to an increasing extent. The development of processing methods will also aid in lowering the cost. The combined effect of these two factors may cut the price roughly in half, but probably not much more for some time to come.

Mention also must be made in this respect to the new reduction processes being investigated that promise significant price relief for the future. However, because reports on these new methods indicate they are still far from the production stage, optimism might best be restrained until work has progressed further.

It is now well recognized that titanium and its alloys are taking their rightful places among the useful engineering metals. Although there still remain many problems to be studied and overcome, the work accomplished in the last few years indicates that future development will result in the increasing use of this new metal for applications in which its peculiar combination of properties is best adapted.

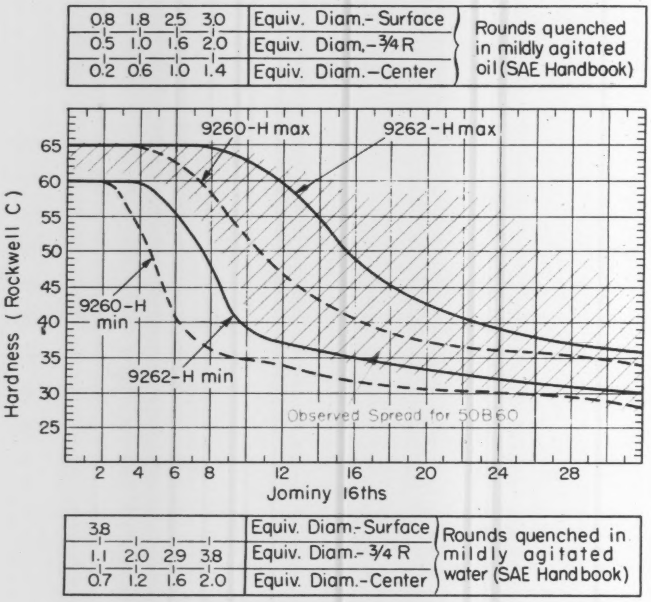
BORON STEELS

H. B. Knowlton

Chief Engineer, Materials Engineering, International Harvester Co., is also chairman of the SAE Iron and Steel Technical Committee, Div. VIII on Boron and Other Alternate Steels. From these dual vantage points, he gives an optimistic report on the current status of boron-treated steels.

DURING the last two years a great deal of thought has been given to the use of boron as an alloying element in the production of automotive steels. Boron is now being added to about 12 per cent of these steels. Some users are now purchasing as high as 60 to 80 per cent of their alloy steel requirements in boron types.

In a discussion of boron steels, it should be empha-



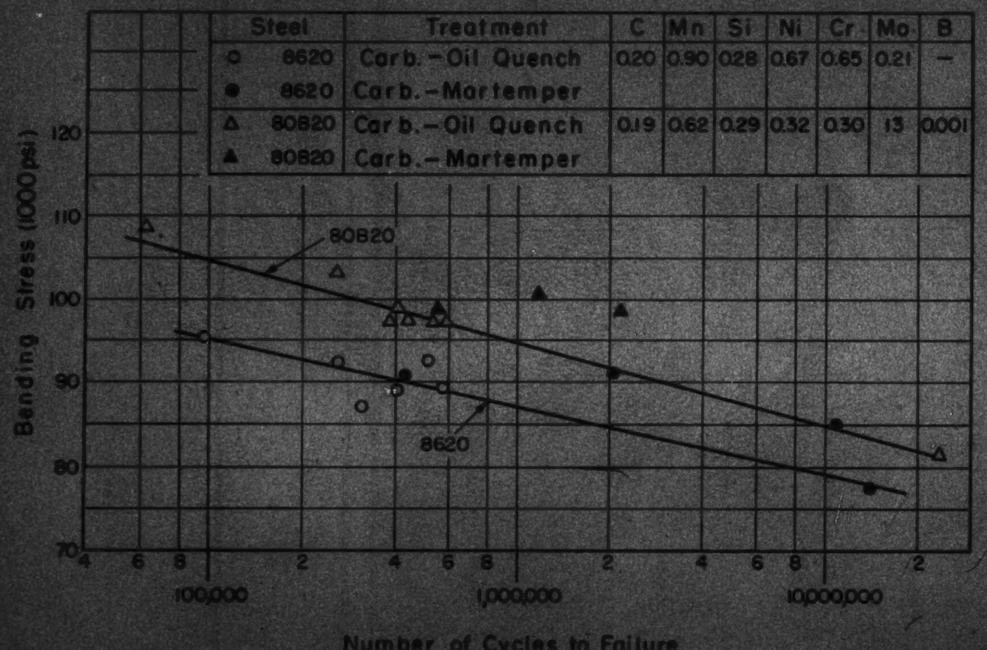
Steel	Description	C	Mn	Si	Ni	Cr	Mo	B
50B60	Min specified	0.55	0.75	0.20	----	0.40	----	Yes
	Max specified	0.65	1.00	0.35	----	0.60	----	Yes

Fig. 6—Hardenability chart comparing spread of 251 heats of boron grade 50B60 with maximum and minimum limits for 9260-H and 9262-H. Data, courtesy Wisconsin Steel Works

sized that boron does not add any mysterious new properties to steel. Parts made from this type of steel are not radically different from those produced from other steels. Boron is one of several elements which are employed for producing steel of the desired hardenability. It has an advantage over the other hardening elements in that a very tiny amount of boron has a large effect upon the hardenability: 0.002 per cent of boron is equivalent to 2.00 per cent of nickel, or 0.50 per cent chromium. The country which can make the most economical use of alloying elements should be able to manufacture the greatest quantity of military materiel, and at the same time produce the greatest volume of civilian products without jeopardizing the quality of either. Such a country should be in the best position to win the next war or the next peace.

It may be well therefore to discuss boron steels on the basis of their use in place of older types of alloy steel, rather than on the basis of new properties which probably do not exist. For about two years, Division VIII of the SAE Iron and Steel Technical Committee has been conducting a series of open forum discussions of the properties and applications of boron steels. As many as 150 metallurgists have participated in some of these discussions. In this article an attempt will be made to summarize some of this information, supplemented by experiences within the International Harvester Co.

For many years alloying elements, such as nickel, chromium, molybdenum, and vanadium, have been added to automotive steels in order to produce cer-



Steel		Treatment	C	Mn	Si	Ni	Cr	Mo	B
○	8620	Carb.-Oil Quench	0.20	0.90	0.28	0.67	0.65	0.21	—
●	8620	Carb.-Martemper							
△	80B20	Carb.-Oil Quench	0.19	0.62	0.29	0.32	0.30	13	0.001
▲	80B20	Carb.-Martemper							

Fig. 7—Stress versus cycles to failure of 8620 and 80B20 10-pitch gears. Data, courtesy Widrig and Groves, Spicer Mfg. Co.

tain desired ranges of hardenability. The maximum hardness which may be produced by quenching is dependent upon the *carbon content,* but the *rate of cooling* necessary to produce this hardness is dependent upon the *hardenability* which is affected by both carbon and alloy contents. The higher the hardenability, the less drastic is the quench required to produce the desired hardness.

With alloy steels it is frequently possible to employ oil quenching. Oil, water or brine quenching might be necessary with plain carbon steels. Slower quenching may mean less distortion, warping, and residual stresses. It should be mentioned in passing, however, that special treatments, such as torch or induction hardening, time quenching, etc., applied to plain carbon steels may develop good physical properties and stress distribution, if the process is expertly controlled.

Boron steels are not new. International Harvester's mill, Wisconsin Steel, has been working with boron additions for about 15 years. During World War II it produced 92B62, a boron silicon manganese steel, for certain ordnance parts with excellent results. At present a number of steel companies are producing several families of boron steels, TABLE 1. The 80B00 and 50B00 steels have hardenability equivalent to the 8600 steels, while the 86B45 is being used by one tractor manufacturer to replace 4340. Also, 14B00 carbon boron steels are used to replace the lower hardenability alloy steels, particularly for bolts.

Heat-Treated Parts: In general, boron steels have

Table 1—Chemical Composition Limits of Boron Steels*

(per cent)

Grade	C	Mn	Si	Ni	Cr	Mo	V
TS 14B35	0.33-0.38	0.75-1.00	0.20-0.35	......	......	......	......
TS 14B50	0.48-0.53	0.75-1.00	0.20-0.35	......	......	......	......
14B52	0.47-0.55	1.20-1.55	0.20-0.35	......	......	......	......
TS 40B37	0.35-0.40	0.70-0.90	0.20-0.35	......	......	0.08-0.15	......
TS 43BV12	0.08-0.13	0.75-1.00	0.20-0.40	1.65-2.00	0.40-0.60	0.20-0.30	0.03 min.
TS 43BV14	0.10-0.15	0.45-0.65	0.20-0.35	1.65-2.00	0.40-0.60	0.08-0.15	0.03 min.
TS 46B12	0.10-0.15	0.45-0.65	0.20-0.35	1.65-2.00	......	0.20-0.30	......
50B15	0.12-0.18	0.70-1.00	0.20-0.35	......	0.35-0.60	......	......
50B20	0.17-0.23	0.70-1.00	0.20-0.35	......	0.35-0.60	......	......
50B30	0.27-0.34	0.70-1.00	0.20-0.35	......	0.35-0.60	......	......
50B35	0.32-0.39	0.70-1.00	0.20-0.35	......	0.35-0.60	......	......
50B37	0.34-0.42	0.70-1.00	0.20-0.35	......	0.20-0.40	......	......
50B40	0.37-0.45	0.70-1.00	0.20-0.35	......	0.35-0.60	......	......
50B44	0.42-0.50	0.70-1.00	0.20-0.35	......	0.35-0.60	......	......
TS 50B46	0.43-0.50	0.75-1.00	0.20-0.35	......	0.20-0.35	......	......
50B49	0.47-0.55	0.70-1.00	0.20-0.35	......	0.20-0.40	......	......
TS 50B50	0.48-0.53	0.75-1.00	0.20-0.35	......	0.40-0.60	......	......
TS 50B60	0.55-0.65	0.75-1.00	0.20-0.35	......	0.40-0.60	......	......
80B15	0.12-0.18	0.60-0.90	0.20-0.35	0.20-0.40	0.15-0.35	0.08-0.15	......
80B17	0.14-0.20	0.60-0.90	0.20-0.35	0.20-0.40	0.15-0.35	0.08-0.15	......
80B20	0.17-0.23	0.60-0.90	0.20-0.35	0.20-0.40	0.15-0.35	0.08-0.15	......
80B25	0.21-0.28	0.60-0.90	0.20-0.35	0.20-0.40	0.15-0.35	0.08-0.15	......
80B30	0.27-0.34	0.55-0.80	0.20-0.35	0.20-0.40	0.15-0.35	0.08-0.15	......
80B35	0.32-0.39	0.65-0.95	0.20-0.35	0.20-0.40	0.15-0.35	0.08-0.15	......
TS 80B37	0.35-0.40	0.75-1.00	0.20-0.35	0.20-0.40	0.20-0.35	0.08-0.15	......
80B40	0.37-0.45	0.70-1.00	0.20-0.35	0.20-0.40	0.15-0.35	0.08-0.15	......
80B45	0.42-0.50	0.70-1.00	0.20-0.35	0.20-0.40	0.15-0.35	0.08-0.15	......
80B50	0.47-0.55	0.70-1.00	0.20-0.35	0.20-0.40	0.25-0.50	0.08-0.15	......
80B55	0.50-0.60	0.70-1.00	0.20-0.35	0.20-0.40	0.30-0.55	0.08-0.15	......
80B60	0.55-0.65	0.70-1.00	0.20-0.35	0.20-0.40	0.30-0.55	0.08-0.15	......
81B35	0.32-0.39	0.70-1.00	0.20-0.35	0.20-0.40	0.30-0.55	0.08-0.15	......
TS 81B40	0.38-0.43	0.75-1.00	0.20-0.35	0.20-0.40	0.35-0.55	0.08-0.15	......
81B45	0.42-0.50	0.70-1.00	0.20-0.35	0.20-0.40	0.30-0.55	0.08-0.15	......
81B50	0.47-0.55	0.75-1.05	0.20-0.35	0.20-0.40	0.35-0.60	0.08-0.15	......
TS 94B17	0.15-0.20	0.75-1.00	0.20-0.35	0.30-0.60	0.30-0.50	0.08-0.15	......
TS 94B20	0.17-0.22	0.75-1.00	0.20-0.35	0.30-0.60	0.30-0.50	0.08-0.15	......
TS 86B45	0.43-0.48	0.75-1.00	0.20-0.35	0.40-0.70	0.55-0.75	0.08-0.15	......

*These steels can be expected to have 0.0005 per cent minimum boron content.

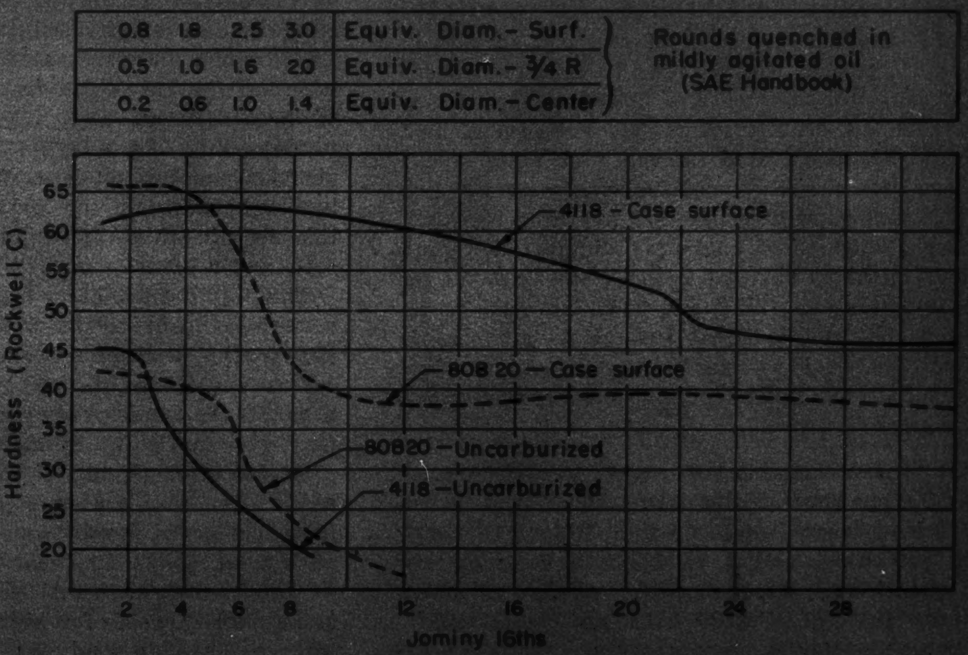


Fig. 8—Hardenability chart comparing case surface of grades 4118 and 80B20 and same grades uncarburized

been satisfactorily substituted for conventional 0.30-0.60 per cent carbon alloy steels on the basis of duplicating the hardenability. Many of the useful properties of heat treated steel parts are dependent directly, or indirectly, upon the cross sectional hardness, which in turn is dependent upon carbon content and hardenability of the steel. Strength is directly proportional to hardness; toughness is somewhat inversely proportional to strength and hardness. The best combination of hardness and toughness is obtained when the steel is fully hardened before tempering. Many production parts, however, do not meet this ideal requirement. In substituting boron steels, it is usually satisfactory to duplicate the hardness and toughness of the original part.

The type and magnitude of residual stresses set up by heat treatment have a pronounced effect upon the final performance of any heat-treated part. Substituting boron steels on the basis of equivalent hardenability usually means that they will respond in the same way to heat treatment and will set up similar internal stresses. This fact does not apply, however, to case-hardened parts, as will be discussed later.

Boron replaces the hardenability function of other elements but will not duplicate other properties, such as corrosion and heat resistance, or cold impact strength. Where other alloy steels have been specified for these purposes, boron steels may not be satisfactory substitutes. Molybdenum steels in particular have been known for high notch toughness at subzero temperatures. While the boron steels may not duplicate these properties, they have frequently been found to have adequate notch toughness for many commercial applications, even at low temperatures.

The following are typical examples of successful applications of boron steels.

Springs: Grades 80B60, 50B60, and 51B60 have been used satisfactorily for leaf and coil springs in trucks and tractors. *Fig.* 6 shows the observed hardenability band for 251 heats of 50B60 in comparison with 9260-H. Laboratory fatigue tests and actual field service have demonstrated the merit of these steels. 51B60 has been similarly used for springs over 1-inch thick. No trouble with brittleness has been reported. The meager amount of cold notch impact test data submitted indicates that the boron steels have higher notch toughness than 9260 and 9262. It must be remembered that coil and leaf springs do not contain sharp notches, such as used in the impact test bar. Consequently cold notch toughness is probably not a determining factor.

Bolts: For a number of years the Caterpillar Tractor Co. has successfully used 14B35 boron carbon steel for heat treated bolts up to 7/16-inch diameter for oil quenching, and 1 to 1¼-inch diameter for water quenching. More recently others are using 14B35 for 4037, 8630, 2330 bolts. A special 40B37 is recommended for the manufacture of bolts involving difficult heading operations.

Other Heat-Treated Parts: Reports indicate that boron alloy steels are being satisfactorily substituted for a large variety of heat-treated automotive parts on the basis of duplicating the hardenability of the original steel. It is still a safe recommendation, however, to make simulated service tests of any part under consideration before substituting boron steels.

Processing Characteristics: Little difference has been reported in the forgeability and machinability, or weldability of boron steels in comparison with other steels of similar hardenability. There may be some tendency for the boron steels to be slightly softer after normalizing. Boron steels may not show the same resistance to tempering as some other alloy steels; consequently it may be necessary to lower the tempering temperature 50 degrees or more, to obtain the customary final hardness.

Case-Hardening Steels: Several automotive firms have been successful in making certain types of case-hardened gears with boron alloy steels. *Fig.* 7 shows the results of dynamometer tests on gears made of 80B20 as reported by Widrig and Groves of Spicer Mfg. Co. It will be noted that the boron steels gave as satisfactory performance as 8620. Others have reported considerable difficulty with distortion of the boron steels during the case-hardening process. This is probably due to the fact that boron has much more effect upon the hardenability of the core than it does upon the hardenability of the case. This condition is illustrated by *Fig.* 8.

Nickel, on the other hand, has a much greater effect upon the hardenability of high-carbon than of low-carbon steels. It is probably for this reason that the high-nickel steels, such as 4815, and to some extent 4615, excel in their ability to produce high hardness on the surface of very large gears and pinions with oil quenching after carburizing. Substituting boron steels which have the same hardenability in the core will not guarantee the desired hardness in the case of large sections. Boron, however, does increase the hardenability of the layers in the case which are 0.70 per cent carbon or less. Consequently it produces higher hardness in the lower layers of the case, and this may be valuable in preventing crumbling of the case under severe loads.

The high hardenability of the core with boron steels sometimes leads to distortion and other difficulties. This may be overcome to some extent by lowering the carbon content of the steel, thus lowering the hardness of the core. Very-low-carbon steels, however, may give difficulty in machining.

On the whole, it may be found that the use of boron steels for case-hardened parts, particularly case-hardened gears, involves more problems than the use of similar steels for heat-treated parts. It should be emphasized, however, that boron steels are being satisfactorily used for certain case-hardened gears after a thorough study has been made of individual problems.

RUBBER AND SYNTHETICS

Karl P. Goodwin

Sales Mgr., Acushnet Process Co., draws also from a diversified engineering and production background in depicting the effects upon design of recent advances in the technology of rubber and synthetics.

RUBBER compounding today is on a new threshold. With the introduction of new synthetic polymers, and new natural rubber compounding techniques, the compounder and designer have been given an increasingly wider field for development and experimentation. This fact is generally recognized by a large percentage of rubber users, but there are many who do not realize that rubber has become an ideal material for applications in which it would have been unsatisfactory only a few years ago. Recent developments contributing to rubber's increasing versatility as an engineering material are briefly reported in this article. Topics include new techniques and equipment as well as rubber materials.

Natural Rubber: There have not, of course, been any substantial changes in the methods of producing natural rubber over the last year or two, nor are there any major changes in the physical properties obtainable from the natural product. However, great strides have been made in the classification and gradation of rubber, and there are today types commercially available which are extremely advantageous to the manufacturer who wishes to be certain of the consistent physical properties in his product.

Known as TC Rubber (Technically Classified Rubber), these grades of rubber can be purchased with certain physical properties of the lot tested and certified. The use of such rubber should minimize the once-common difficulty of obtaining consistent properties from different batches of natural material.

TC Rubber is tested in the East Indies for its modulus at an elongation of 600 per cent. Depending on the results of this test, the lot of material is segregated into one of three classifications. In like manner, a sample from the lot is tested for its Mooney plasticity and separated into one of three classifications. If, in a given product, all the manufacturing variables are carefully controlled and, in addition, TC rubber is used, reasonably consistent physical properties can be expected. Control of modulus and plasticity makes it possible to anticipate reasonably uniform hardness, tensile strength, elongation, etc.

Cold Rubber: GR-S, or Buna S, is the general-purpose rubber. Made in the largest volume during World War II it became, and still is, the generally used substitute for natural rubber. Superior in some respects to natural rubber, it is inferior in others.

In recent years, however, the development of "cold rubber" has substantially improved the tensile strength and the abrasion resistance over that of the more general types of GR-S, and has overcome some of the objections to the material. The earlier types of GR-S were polymerized at about 120 F, whereas cold rubber is polymerized at a temperature in the neighborhood of 40 F.

A number of companies who were forced back to the use of GR-S during the rubber shortage of the last year and a half, and who are once again able to use natural rubber in their product, prefer to stay with the later types of GR-S even though the price of natural rubber has today dropped to a point where there is little, if any, cost advantage in the use of GR-S.

Because of the natures of the sources of supply of GR-S and natural rubber, it is unlikely under present conditions that natural rubber will ever sell at a substantially lower price than GR-S. On the other hand, it is entirely possible, and perhaps probable, that natural rubber will once again sell at a substantial premium over GR-S within the next few years. It is, therefore, advisable that users of natural rubber who have been unable to find a GR-S compound to do their job should continue in their search for it.

The constant improvement not only in the raw material GR-S, but in its compounding, has made possible many applications in which natural rubber was considered indispensable only a few years ago. It is not uncommon today for cold rubber stocks compounded with carbon black to have tensile strengths in excess of 3000 psi. A number of manufacturers of pipe gaskets for use in the transmission of water, sewage, natural gas, manufactured gas, etc., who, during World War II considered the use of synthetic rubbers as entirely impractical, are now using GR-S compounds in their product in preference to natural rubber.

Silicone Rubber: Silicone rubber has been commercially available for the past five or six years. However, during the first of these years, while the material had excellent properties, particularly with respect to its ability to resist deterioration at extremely high temperatures, and its flexibility at low temperatures, it was extremely difficult to fabricate. Over the last year or two, tremendous strides have been made with respect to the moldability and extrudability of silicone rubber.

Illustrated in *Fig.* 9 is an oxygen mask face piece which has been molded from one of the silicone rubbers and which represents as complicated a piece of molding, shapewise, as is ordinarily encountered in regular commercial molding. Two years ago, it would have been considered entirely impossible to mold such a complex piece from silicone rubber, because when hot this material has poor tear resistance. The materials available a year or so ago would have torn during the process of stripping the mask from the mold or during the process of removing the steel cores which form the air ducts in the mask.

Silicone rubbers not only withstand unusually extreme temperatures but, also, possess good dielectric properties, are resistant to many chemicals, and have good resistance to ozone and oxidation, fungus, etc. Silicone rubber does not have as good tear resistance, or as good tensile strength, as many of the other synthetic rubbers or as natural rubber. However, in these respects, also, it has been tremendously improved over the last several years.

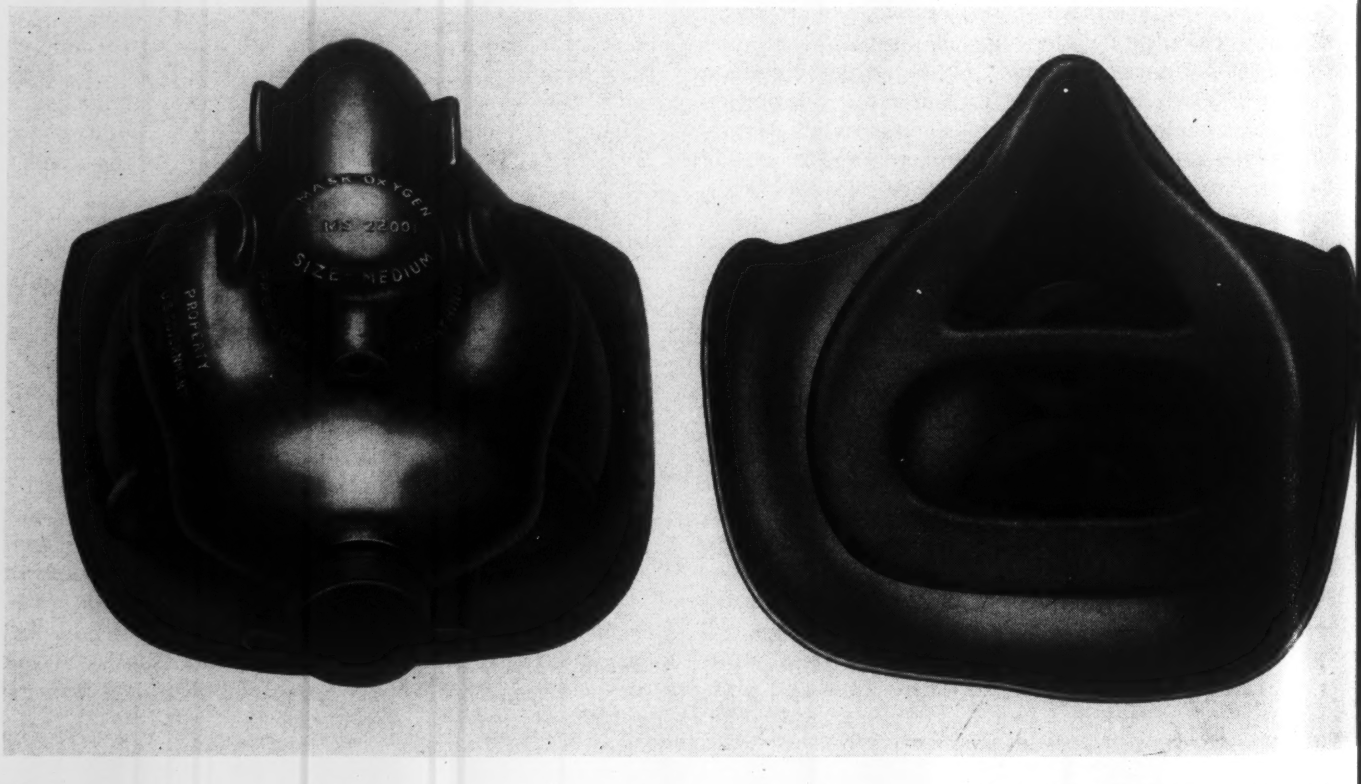
Following is a list of chemicals to which one or another of the silicone rubbers is considered unusually resistant:

- Acetic acid
- Acetone
- Ammonia, liquid
- Ammonium hydroxide
- Freon 114
- Hydrochloric acid
- Hydrogen peroxide
- Mineral oil
- Nitric acid
- Sodium carbonate
- Sodium chloride
- Sodium hydroxide
- Sulfuric acid
- Water

Neoprene: A new neoprene polymer identified as Neoprene WRT has been developed which is superior in some respects to the earlier types. In particular, Neoprene WRT has substantially better compression set or drift characteristics than Neoprene GN.

Other types of neoprene have given trouble in cold applications due to a progressive crystallization of the polymer at low temperatures which has resulted in a gradual hardening of the compound or molded part. Neoprene WRT is greatly improved over earlier types in this respect, also.

Fig. 9—Oxygen mask face piece which exemplifies complexity of molding now feasible with new silicone rubbers having improved tear resistance



The new polymer at the present time sells for approximately 7 cents per pound more than the conventional types of neoprene.

Hycar PA: Hycar PA is a polymer of an acrylic acid ester. At present, it is somewhat less expensive on a weight basis than the silicone rubbers. It has excellent resistance to flexing and extremely good resistance to sunlight and ozone. Its heat resistance is superior to most of the conventional rubber and synthetic rubber compounds, but is not as high as the silicones. It has good resistance to many hot oils.

To date, this polymer has been available only in limited quantities and is still so new that many possible applications have not yet been explored. However, it has been used successfully in applications where high heat resistance and oil resistance are essential, and already has sufficient background to make it a material which can be safely used.

Hypalon S-2: Hypalon S-2 is an entirely new Du Pont material with which, to our knowledge, there has not been a substantial amount of experience in quantity production. It is a chlorosulfonated polythene. It is reported that it can be molded by either compression or injection methods with conventional rubber molding equipment. Of course, the properties of products made from it depend not only on the polymer itself but also, as with all rubberlike materials, on the ingredients with which the polymer is mixed.

In general, however, it is reported that compounds can be developed with Hypalon S-2 having the following properties: tensile strengths ranging to 3500 psi; shore A durometer readings from 60 to 95 or somewhat softer if mixed with plasticizers such as natural rubber; extremely good ozone resistance and extremely good abrasion resistance; good flex life; good heat resistance, and good outdoor weathering properties. The compounds made from the material tend to have a higher modulus than most of the commonly used polymers.

Rubber-Metal Adhesions: New thermosetting types of adhesives have been developed in recent years which have multiplied, by many times, the bond strength that can be obtained between rubber, or synthetic rubber compounds, and metal components. For many years, it has been general practice to make, for example, rubber-to-metal engine mountings and similar vibration absorbing mounts by using hard rubber tie gums, or thermoplastic adhesives, or by brass plating the metal components of the mount, and putting them in a mold with uncured rubber stock. As the rubber is vulcanized, a bond between the two materials is obtained.

Because of variations in the shape of the parts involved, or in the types of metal used, or in other limiting factors which might affect the type of bond that can be obtained, it is difficult to state in definite terms what can be expected of bond strength between any specific materials. For purposes of comparison, however, it might be said that rubber stocks bonded to metal components without the use of adhesives may be expected, in the case of soft compounds, to develop a bond strength of 50 psi or better. Under ideal conditions, and by using adhesives, adhesion values as high as 2000 psi (measured by ASTM Adhesive Test D429-47T) can be obtained.

In the use of these materials it is essential that, first, the metal inserts or components be chemically clean. This is accomplished by such procedures as pickling, air or mechanical blasting with sand or metal particles, and chemical cleaners. After cleaning, adhesive is applied or in certain cases the metal components are brass plated to obtain adhesion to the rubber. Adhesives are applied to the metal by dipping, brushing or spraying, and dependent on the nature of the adhesive, the material can be applied at either room or elevated temperatures. After cementing, care is taken to protect inserts from foreign materials or contamination prior to molding. The raw stock is compounded to give the best adhesion and, to meet customer specifications for the part, must be used or vulcanized within a specified period of time after mixing.

In TABLE 2 are outlined the results that Acushnet has been able to obtain under ideal conditions. It must be borne in mind, however, that in many cases when it is necessary, for example, to use an adhesive or a compound which is suitable for resistance to heat, fuels or some other unusual condition, the selection of those materials might make it impossible to obtain as good a bond as indicated by this table. The shape of the parts involved also often sets a limit on the type of bond obtainable.

Because success or failure of the bonded application depends to such a great degree upon the design of the part involved, it cannot be too strongly recommended that the designer consult a competent producer of rubber-to-metal adhesions while the design is in its initial stage. The following suggestions might

Table 2—Comparative Strength of Rubber-Metal Bonds*

Metal	Natural Rubber	GR-S	Neoprene	Nitrile Rubber	Butyl Rubber	Silicone†
Black iron ...	Good	Good	Good	Good	Fair	Good
Steel	Good	Good	Good	Good	Fair	Good
Aluminum ...	Good	Good	Good	Good	Fair	Good
Stainless steel.	Good	Good	Good	Good	Fair	Good
Lead	Poor	Poor	Poor	Poor	Poor	....
Copper	Fair	Fair	Fair	Poor	Poor	....
Dow Metal...	Good	Good	Good	Fair	Fair	....
Zinc	Good	Good	Good	Good	Fair	....
Brass (70/30)	Good	Good	Good	Fair	Fair	Good
Brass Plate...	Good	Good	Fair	Fair	Fair	....
Carbon‡	Fair	Fair	Fair	Fair	Fair	....

*Ratings are based upon the strength of the rubber material. "Good" means adhesive bond strength equal to or greater than that of the rubber. "Fair" means less than the rubber strength but sufficient for some applications. "Poor" means bond strength satisfactory only where slight adhesion is required.

†Constant "good" due to low tear and tensile strength of the polymer itself.

‡Bond failures occur when the insert (carbon) breaks.

well be borne in mind during the design of the component.

The metal portions should be designed with thought to their location in the mold. The surfaces which will come in contact with the mold must be as accurate as it is expected to have the metal component located in the rubber. Spaces in the cavity of the mold which are not occupied by metal will be necessarily occupied by the rubber compound itself, and if it is necessary to have areas of the metal free of rubber, they must either hug the walls of the mold, or the rubber will have to be removed from the metal surfaces later. In many cases, these cleaning operations are costly.

The surface of the metal component which is in contact with the rubber and which will be placed under stress, should be as uniform as possible. Holes or projections from this metal surface may cause concentration of stresses, and will start failures in the bond at lower load values than would be obtained if these stresses were distributed uniformly over the surface of the metal parts.

Sharp corners, either external or internal, should be avoided wherever possible. Internal sharp corners invariably result in stress concentrations at these points. All holes or undercuts in rubber parts must be formed by portions of the mold which occupy these spaces during molding, and it must be possible to remove these metal portions of the mold from the finished product.

Although draft is not necessary in most molded rubber products that are made without metal components or attachments, draft is essential in many spots where the stretching of the rubber is restricted by the metal component.

Transfer and Injection Molding: Much progress has been made in the past several years in the field of mold design, particularly in the methods of transfer and injection molding thermosetting materials such as rubber and synthetic rubbers. Molds designed for these methods are empty when closed in the press and are held closed by a clamp or hydraulic press while the raw rubber stock is forced into the cavities through sprues or channels.

The term transfer molding is generally used to define the mold which performs this operation in a conventional compression type press, providing such a press has sufficiently high clamping pressure to hold the mold closed against the pressure of the material being molded inside it.

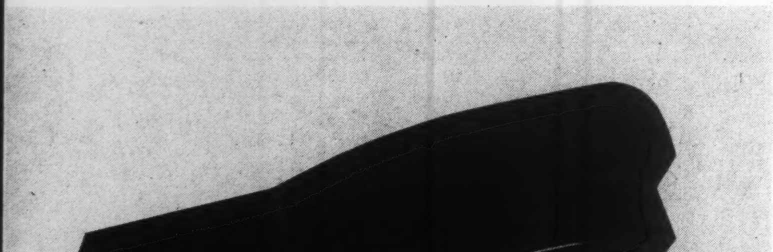
This method virtually eliminates the flash or excess rubber on the molded product, as well as the variations which previously have always been inherent because of variations in the thickness of the flash. These advantages, unattainable by conventional compression molding, permit the production of parts requiring a high degree of accuracy with a minimum variation in thickness. In addition, by eliminating the operation of flash removal, cost savings result in many instances. However, as constant high pressure must be maintained during the molding operation, transfer molds normally have fewer cavities than molds operated by the older compression methods. This factor and the cost of cleaning out sprues between heats tend to offset the savings in flash removal. On the other hand, certain type cavities in transfer molds can be loaded by using one slug of stock for several cavities, whereas, in compression molding each cavity requires individual loading.

Transfer and injection molding are similar insofar as both have stock introduced into the cavity through sprues while the mold is closed at all parting lines. However, injection molds require not only clamping equipment such as toggle-action link clamps or hydraulic ram systems, but they also require an external mechanism to supply the force necessary to propel the stock through the sprues. Transfer molds are designed to make dual use of the closing force of a hydraulic press for these functions.

The advantages of these methods are more pronounced when it is realized that by their use it is possible to mold metal inserts in rubber parts, which, if molded by the compression method, would in most cases become dislocated, damaged or destroyed.

As discussed previously, when metal inserts are molded in rubber parts, sufficient contact must be provided between the inserts and the faces of the mold to assure positive location of the inserts. Frequently the shapes of the metal inserts and rubber parts are such that positive location can only be obtained when the mold is closed, since the locating surfaces are distributed between several surfaces of the mold. Thus in compression molding, if the inserts were put in place and cold stiff stock were forced against them before they were securely anchored, they would in many instances drift out of place and be damaged, or damage the mold when it was completely closed. Also, the molded part itself would be unsatisfactory. In transfer or injection molding, of

Fig. 10—Rubber components with thin slot through thick section typifying practice possible by transfer or injection molding



course, the mold is completely closed before the pressure of the heated, softened stock comes against the metal inserts.

In like manner, other parts not having metal components may require thin slots or sections formed by portions of the mold that are extremely delicate except when completely supported by other components of the mold. An example of such a part is illustrated in *Fig.* 10. The thin, through-slot in this part can not be put in after molding because of the irregularities and thickness.

Extrusion Molding: In recent years, so-called cold-feed tubers have been developed which have increased the accuracy obtainable in the cross-section dimensions of most extrusions. In conventional extrusion equipment, the mixed stock must be warmed and milled to a uniform plasticity on milling equipment generally located adjacent to the extruder. Variations in the length of time the stock remains on the mills result in variations in the softness of the stock when extruded which, in turn, are reflected in differences of the cross-section dimensions of the finished extrusion.

The cold-feed extruder makes possible feeding of cold stock into the extruder where it is plasticized and warmed during its passage through the machine. All batches of stock, therefore, pass through the same cycle and can be expected to have nearly the same degree of plasticity.

Curing: Dielectric heaters have been used in recent years to speed up the cure and lower the cost of rubber parts having thick cross sections. Because of the time involved in heating such thick rubber parts uniformly, previously long periods were required to properly vulcanize such parts. Dielectric heaters, which internally heat the uncured material before it is molded, reduce by many times the period necessary to hold such a part in the mold or press equipment. As a result, more uniformly cured products of thick cross sections can be expected.

MAGNESIUM ALLOYS

James V. Winkler

Head, Magnesium Sales Dept. Tech. Service and Development, Dow Chemical Co., is responsible for Dow's development of new applications for magnesium. Experienced also in process development in the forming and fabricating of magnesium as well as field sales work, he reports the industry's advances particularly pertinent in design.

PROGRESS in the development of new alloys, fabrication of wrought products, joining, and allied techniques have all played an important role in making magnesium one of the common structural metals. Growth curves of four major metals are shown in *Fig.* 11. At the present rate of growth it is anticipated that consumption of primary magnesium shall have reached a total of at least 100,000 tons per year by 1960. A factor in the growth of magnesium is the abundance of a source of supply for the metal. Magnesium ores such as magnesite and dolomite are widely distributed and in large supply. And the ocean contains a virtually unlimited supply of magnesium.

New Alloys: It has long been known that by alloying magnesium with rare earths, alloys having superior properties at elevated temperatures could be produced. Early rare earth alloys had poor foundry characteristics and did not lend themselves to castings of any great complexity. The early alloys were coarse-grained, leading to hot cracking during solidification, and to breakage of the casting in processing it.

To overcome these difficulties, zirconium, a powerful grain refiner, was used. The resultant alloy, Dowmetal EK30, containing 3 per cent total rare earths and 0.25 per cent zirconium, offers a combination of good room-temperature properties with ability to perform at high stress levels in the range of 300 F to 600 F. The development of this alloy is especially

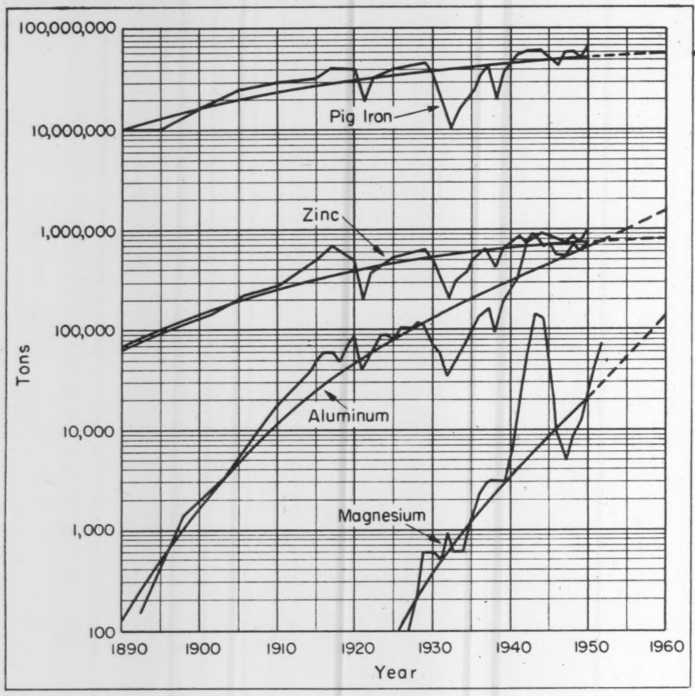


Fig. 11—Consumption of several primary metals in tons per year

important in answering the demand for an ultralight alloy able to withstand the high stresses at high operating temperatures encountered in jet aircraft engines, *Fig.* 12.

In an investigation aimed at developing a commercial extrusion alloy with better strength and toughness than other commercial alloys, alloy additions of zirconium were tried. The possibility of adding zirconium to magnesium-aluminum alloys was quickly eliminated, since zirconium precipitates almost completely in the presence of aluminum. The magnesium-zinc alloys, however, were found to respond well to additions of zirconium.

The resultant alloy, ZK60A, containing approximately 6 per cent zinc and 0.6 per cent zirconium, is an ageable extrusion alloy for use where high strength magnesium extrusions with good toughness are required. Its high mechanical strength is due to the small grain size which zirconium produces and helps maintain. This is not the sole factor, since properties are also dependent to some extent on extrusion conditions, such as temperature, speed, and reduction of cross sectional area. The material possesses, in addition to good strength and toughness, low notch sensitivity and a relatively high resistance to stress corrosion.

One of the most recent developments in the magnesium industry was the initiation of a plant of The Dow Chemical Company at Madison, Ill., for the production of magnesium sheet, extrusions, and alloys. This plant, when completed, will be capable of producing wider and longer sheet than has heretofore been available in magnesium. Latest equipment for rolling, extruding, and ingot casting of magnesium alloys is now being installed. Many operations will be conducted on a mass-production basis for the first time in the history of the magnesium industry.

New and Improved Processes: Magnesium alloy sheet possesses excellent formability when heated dies are used. Forming in the temperature range of 500 to 600 F permits deformations impossible in any other metal and a single draw often is all that is required. Deformations up to 75 per cent are not out of the ordinary. This eliminates the need for multiple sets o dies, speeds up the operation and reduces processing costs even though a preheating of the sheet is required.

Among the newer developments in the draw forming of magnesium has been the discovery of new and improved lubricating agents and better methods for removing the lubricant after drawing. When forming in the temperature range of 500 to 600 F, a colloidal graphite suspended in a suitable carrier such as alcohol or naphtha is very satisfactory. This mixture can be sprayed on the sheet, but a more satisfactory method of applying the lubricant is by roller coating.

Previously, the big disadvantage in using a colloida graphite forming lubricant had been the difficulty encountered in removing the lubricant after forming Now, new means of removal, consisting of a caustic dip followed by rinsing in hot water and chromic nitrate dip, eliminate any vestiges of lubricant.

On deformations requiring lower temperatures up to 400 F, such as in stretch forming, wax lubricants have been developed giving ease of application and removal.

In spite of the preheating of the blank and the heating of the dies, hot forming magnesium is widely accepted. The practice is becoming widespread and is now moving into other metal practices. Shops forming magnesium, titanium, and high strength aluminum perform hot operations on the metals in order to increase formability and to eliminate the number of successive dies required.

Development of applications for welded magnesium has closely paralleled the introduction of new welding equipment for industry. Such developments as the electronically controlled spot welder and the inert-gas-shielded tungsten-arc process have all been applied to magnesium alloys and have increased the fields of application and the acceptance of the metal.

Magnesium sheet and extrusion alloys are readily spot welded. Spot welds in magnesium have excellent static strengths, but fatigue strengths are somewhat lower than for either riveted or adhesive-bonded joints. High-quality spot welds of consistent strength can be obtained, providing material surfaces are properly cleaned and welding machines have closely controlled weld current, electrode pressure and welding time.

Experience indicates that flash welding can be adapted to high-production joining of magnesium. M alloy is difficult to weld because of its narrow solidification range, but FS1, J1 and O1 have been flash welded to obtain joint efficiency of 85 to 95 per cent. Rapid push-up is required because of the high conductivity and narrow freezing range of magnesium. Machines with automatic push-up should be used. The oxide film does not have to be removed prior to welding as is necessary with other types of magnesium welding. No flux or protective atmosphere is required.

The application of the stud-welding process to magnesium has proved feasible. Projections, threaded studs and bosses can be attached to surfaces rapidly and economically.

Arc welding has played an important part in the more than two-fold expansion of magnesium fabrication in the last four years. The inert-gas welding process was developed specifically for use on magnesium in late 1941. This method is still being used, but is not so popular as the modification which makes use of alternating current with high-frequency stabilization. The advantage of alternating current is in the greater current carrying capacity of the tungsten electrode and the resulting greater penetration obtained.

A new operation for magnesium has recently been brought to commercial development. The impact extrusion process for magnesium has reached a point where it is felt that it will become an important fabrication method, to rank with drawing, forging and spinning.

The impact extrusion process for magnesium is essentially the same as for other metals, the main difference being the temperature of operation which in the case of magnesium alloys may vary from 350 to 700 F depending on the alloy and the speed of operation. Basically it consists of four operations: slug preparation, impact extrusion, can trimming and can cleaning.

Thus far, most of the parts have been of the type used in dry-cell batteries. These are round cans in diameters from about 7/16 to 1¼ inches and from 1 to 6 inches in height. Some square cans have been made and there is no reason to believe that parts having flanges, ribs and bosses could not be made.

Some of the advantages of magnesium which bear consideration when looking for impact extrusion applications are light weight, the rigidity of the part, which means that the part can be rough-handled right from the extrusion press without damage, excellent resistance to many organic chemicals and oils, and excellent electrical conductivity.

A process widespread in World War II and again becoming increasingly important is the forging of magnesium alloy parts. Complicated forged shapes are easily produced in magnesium. One of the newer experimental applications of forged magnesium is the large aircraft wheel. The development of the new alloy, ZK6OA, now widely used as a forging alloy, is providing forgings of greater strength and toughness.

Design: Design principles developed originally for magnesium have increased fields of application tremendously. One of the important advances has been in the field of monocoque or stressed-skin construction. This type of design was initiated during World War II for aircraft construction and has been incorporated into many recent aircraft designs and commercial applications.

The most startling development of this design is portrayed by the experimental F-80 wings being manufactured by East Coast Aeronautics Inc., *Fig.* 13. The semimonocoque wings provided greater simplification through the use of magnesium parts of thicker sec-

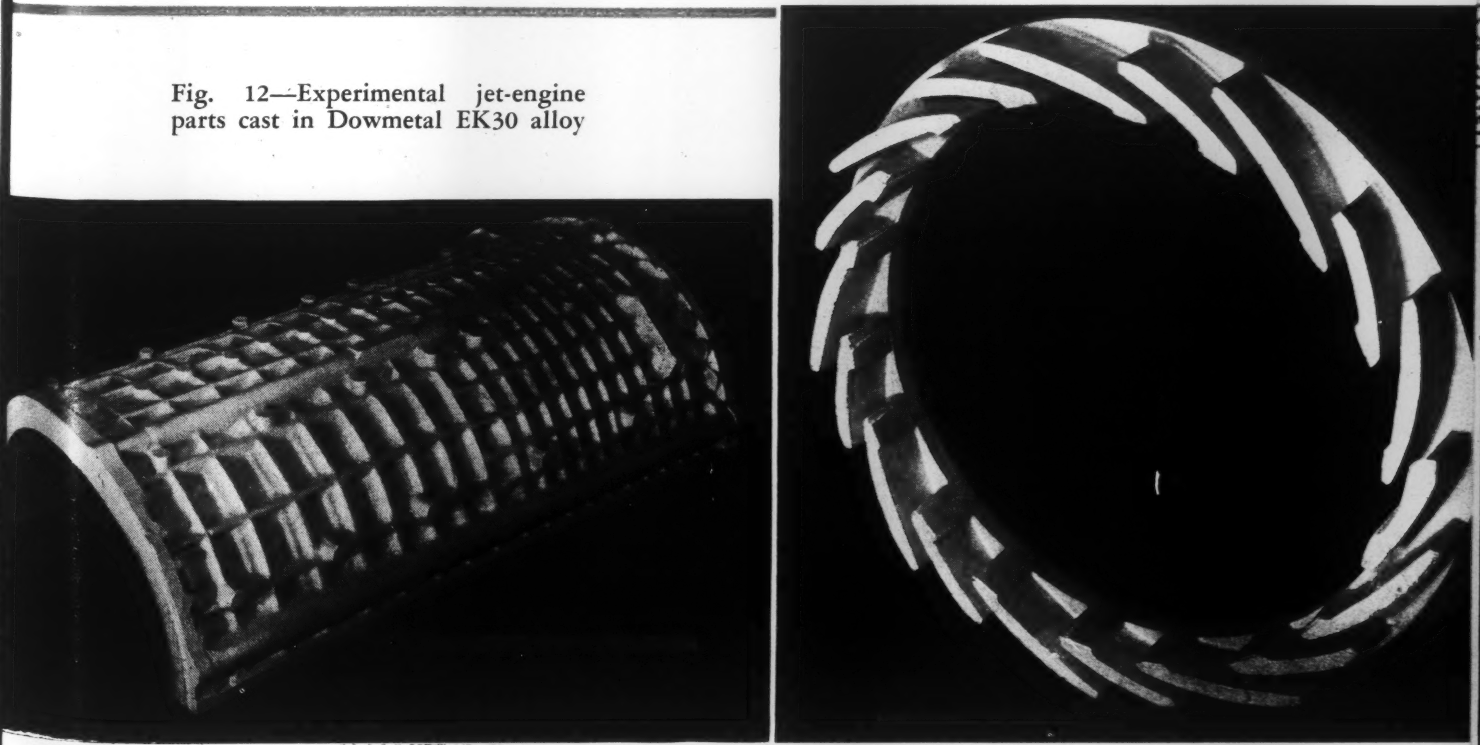


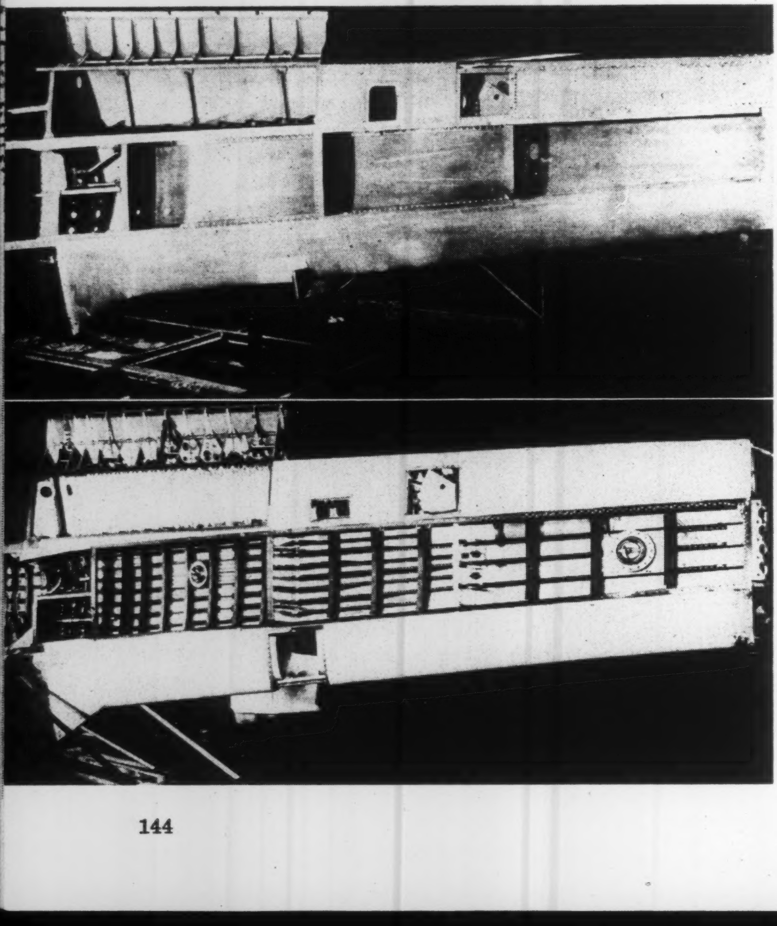
Fig. 12—Experimental jet-engine parts cast in Dowmetal EK30 alloy

tion. The magnesium wing contained 31 per cent of the number of parts and 38 per cent of the number of fastenings contained in the original. Weight saving was not the goal in this application and none was made in the basic structure. Simplification of design, however, reduced the number and complexity of fuel cells and, with all cells installed and full, the wing was 10 per cent lighter than the original. The wing also has improved torsional rigidity and better aerodynamic smoothness than the conventional structure.

This same design was applied to truck body construction. A simplified body was built, using thick skin construction throughout and eliminating a substantial number of the internal stiffeners and braces. The resulting truck body has operated for a number of years with success and has proved to be stronger than the conventional body construction.

Certain basic characteristics of magnesium make the metal an economical choice for die-cast parts. Magnesium castings do not have so great a tendency to solder or adhere to a die as other metal castings do. Consequently, die coating solutions are not necessary and the need for die lubrication is decreased. The chemical affinity possessed by other die casting metals for iron or steel presents handling problems. Magnesium can be transferred in the molten state through steel pipes and would appear to be more readily adapted to automatic metal handling. In amenability to intricate coring, magnesium die castings rank between zinc, which is best, and aluminum. Required draft is greater than zinc but less than aluminum.

Fig. 13—F-80 wing panel in thick skin design, above, and original built-up design, below. Without weight penalty, simplicity and strength were improved and usable space increased. Assembly time and costs were reduced by the elimination of 1132 parts and 26,700 fasteners



A further consideration in magnesium is the fact that it is the easiest of all structural metals to machine. This excellent machinability of magnesium and its alloys permits machining operations at high speeds —usually the maximum obtainable on modern machine tools. Heavier depths of cut and higher rates of feed than are used on other metals are possible when machining magnesium. As a result of these machining characteristics of the metal, the power required to remove a given amount of metal is lower for magnesium than for any other commonly machined metal.

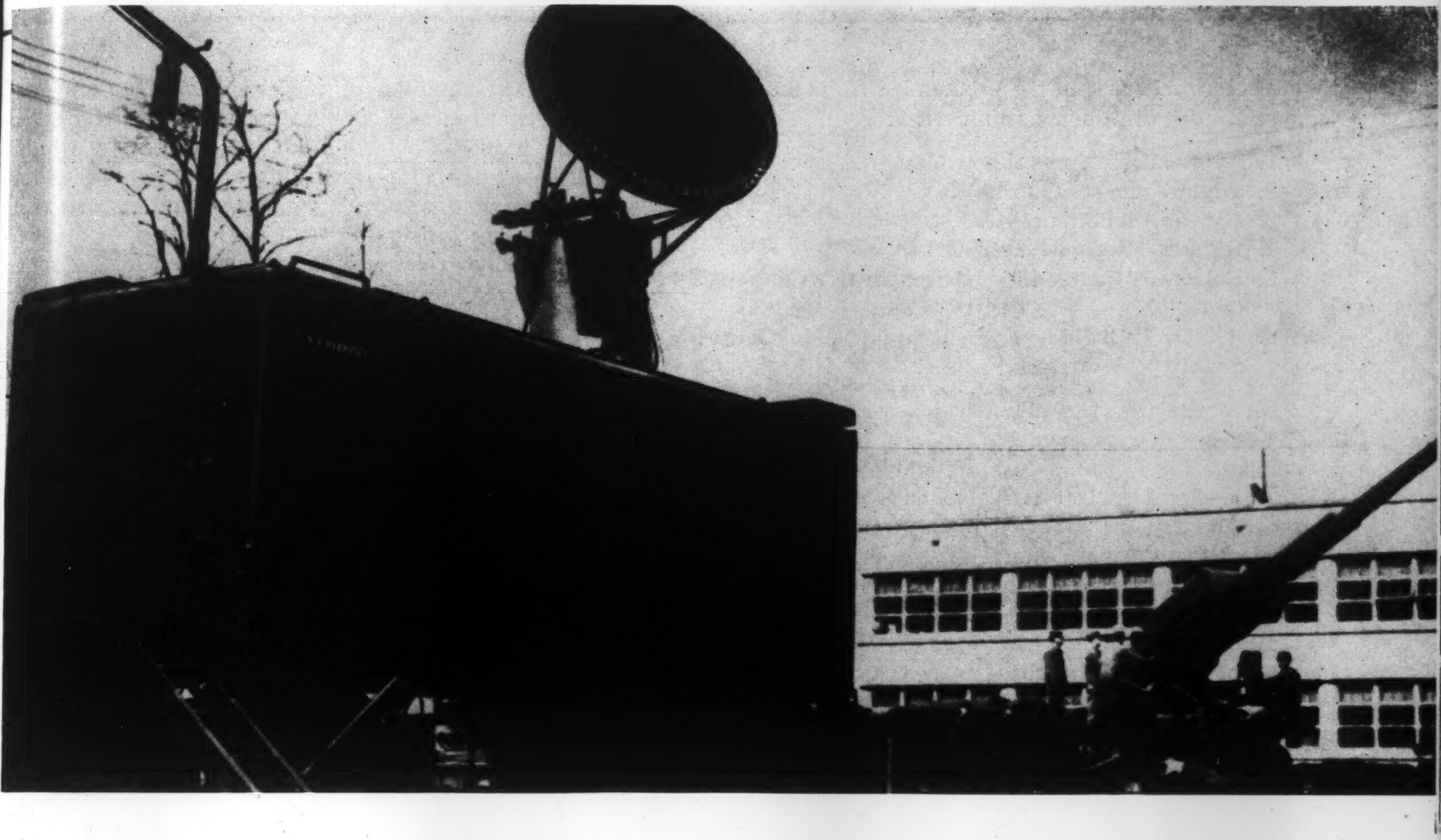
Fig. 14—Radar trailer containing fire-control system far antiaircraft artillery. Trailer and much of the radar equipment inside are constructed of magnesium

Finishing: Although magnesium will stand up well under conditions of atmospheric exposure, for maximum serviceability and appearance it is recommended that suitable primer and finish coats be applied over surfaces which have been prepared by proper chemical treatment. These treatments have been designed for special applications and are felt to be the best for those applications.

The most recent development in the field of finishing is the electroplating process for magnesium. In general, the process consists of the initial deposition of an immersion zinc coating followed by copper striking in a slightly modified copper cyanide bath and electroplating in the standard plating baths. Heavy copper, silver, cadmium, zinc, gold, brass, chrome, and other metal platings may be applied. The stability and protective values of various electrodeposits on magnesium alloys have been found to be excellent.

Applications: One of the most interesting developments in magnesium is the radar trailer unit of the ordnance department. The 21-foot trailer, ***Fig.*** **14**, is almost all magnesium, including frame, covering and even the equipment inside. A radar cabinet utilizing a specially designed extrusion in place of welded sheet and angles is used in this trailer. Another use of a single magnesium extrusion in place of a section built up from sheet and angles is the floor beam for the Douglas C-124.

The largest consumer of die castings in the country is the automotive industry. Its increasing use of magnesium die castings is evidence of the recognition of the utility and economies of magnesium. More and more automotive parts are being switched to die cast magnesium and it is anticipated that this trend will continue.



POWDER METALS

Robert Talmage

Consultant in Applied Powder Metallurgy, presents a summary of recent advances of design significance in this relatively new industry. He has designed and placed in operation sintering plants in this country and abroad, and has served as consultant for metal producers as well as machine manufacturers.

FIRST use of the powder metallurgy technique in the production of mechanical parts dates from about 1937. In that year one of the first manufacturers of porous bronze bearings, Moraine Products Div. of General Motors Corp., began production of ferrous powder parts in competition with the more common processes of casting, forging, etc.

In 1938 production of automotive oil pump gears from iron powder was attempted. The gear had previously been produced from a cast-iron slug by conventional machining methods. Although the tooling cost for this part was quite high, the application was a success and acted as the harbinger of the new powder-metal industry. Other parts had been produced earlier but none approached this gear in its sensational success and acceptance.

Growth of the infant industry was accelerated, of course, by the advent of World War II. A number of factors inherent in the process led to its more widespread adoption during this period:

1. Availability of metal powders
2. Slight or no scrap loss
3. Low unit labor cost
4. High speed of production
5. Relatively long life of reasonably low-cost tools
6. Relatively little equipment required for large-quantity production.

Since the war the industry has continued to grow for these same reasons, *Fig.* 15, and because of developments since then. Cost of popular metal powders has increased little relative to base metal cost while strip and rod costs have increased substantially over the last few years.

Perhaps the greatest overall reason for increasing acceptance of powder metal parts—or *sinterings* as they might better be termed—is the expanding knowledge of successful applications. Growing use of sinterings has been occurring in such industries as the roller chain, business machines, hardware, automotive, clock, etc.

But the course of expansion of the industry has paralleled the path of other new industries—failures have been experienced. Often, the failure has not lain with the process but rather in the understanding of it. It is basically simple: mixing of metal powders, forming of a compact at high pressure, and sintering at high temperature. But because of its deceptive simplicity, the full potentials of the process often are not perceived or realized in the first attempt. Some of the most striking applications of sintering, in terms of reduced costs and improved performance, were developed out of a succession of failures. Growing knowledge coupled with persistence is paying dividends.

Perhaps the designer not familiar with sinterings might well ask, "Why use powder-metal parts?" The answer relates to three primary factors in design: the function of the part, the material from which it is to be made, and the process by which it will be made. Sinterings offer a great range of functional attributes, a wide variety of possible materials, and an inherently versatile production process for which design rules are being rather definitely formulated. In appraisal of new designs or redesigns the relative features of different materials and processes must be astutely compared if required performance is to be met at lowest cost. This article presents a brief report of recent developments in the powder metallurgy field to aid such study.

Materials: Variety, quality and uniformity of metal powders have all been improved in recent years—both in ferrous and nonferrous type. For example, ferrous alloy powders are now available for economical production of parts that previously required difficult alloying of separate elements in the sintering operation. Stainless steel and nickel-steel parts can now be easily produced.

Improvements in physical properties of ferrous parts have been particularly noteworthy. At an earlier day, tensile strength of only 20,000 to 25,000 psi and little ductility were common for steel sinterings. Today, with no speical techniques tensile strength ranging from 50,000 to 75,000 psi is common and ductility is satisfactory.

With special techniques, such as using a repressing and resintering or by impregnating the porous steel structure with copper or other low melting point metals, tensile strengths of more than 100,000 psi are being consistently maintained. These special techniques are usually too expensive for normal use, but have been found economically feasible for special high-stress applications such as jet engine compressor blades.

Sinterings once were criticized for poor tensile fatigue properties, but today the performance of sin-

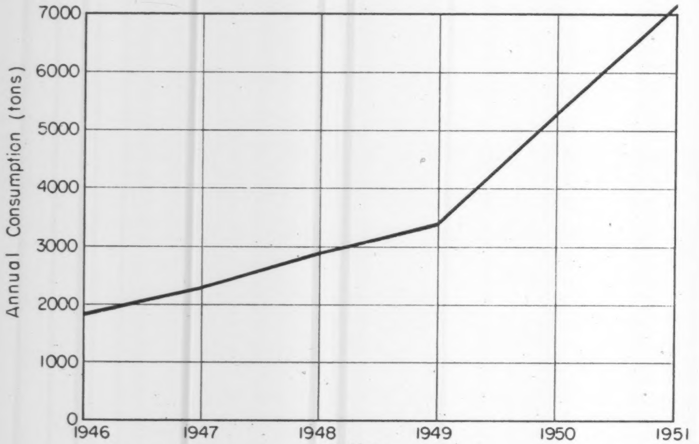


Fig. 15—Curve showing approximate annual consumption of iron powder, paralleling the growth of the metal powder industry since World War II

tered compressor blades, and sintered bushings in roller chain are just two proofs to the contrary. Chain bushing sinterings processed in the usual way approach solid steel in fatigue life. Acting as connectors between link plates and subjected to high intermittent stress, they show long life because of a smooth surface free of stress raisers such as scratches and machining marks.

Hardening of steel sinterings has often presented a problem because of susceptibility to decarburization. The salt bath technique for avoiding this difficulty is not usually successful with sinterings because the salts penetrate the porous structure. Hardening is best accomplished in a carbon potential controlled atmosphere furnace equipped for direct quenching in oil from the atmosphere. With correct hardening, uniform hardness of 45 Rockwell C and higher can easily be obtained. It should be emphasized that this value does not indicate the particle hardness or wear hardness. It is quite possible that with a hardness of 45 Rockwell C the part may be file hard and have a particle hardness of 60C, which is the hardness that influences wear resistance.

Compressibility of steel sinterings and their hardness, smooth surface, and oil retention are leading to many new applications requiring wear resistance. Solid steel of 60 Rockwell C does not conform as readily to a mating part and thus distribute the load over greater area as does a sintered part of 60C particle hardness. This same factor also applies for unhardened parts. In fact, often an unhardened sintering will outwear hardened steel, because of its conformability, smooth surface, and oil-retaining self-lubricating features. This is particularly true of gears. Another factor is that sinterings do not have a thin disturbed metal surface layer such as is present on most machined or ground parts. This surface layer is subject to galling or scoring and is not as wear resistant as the parent metal.

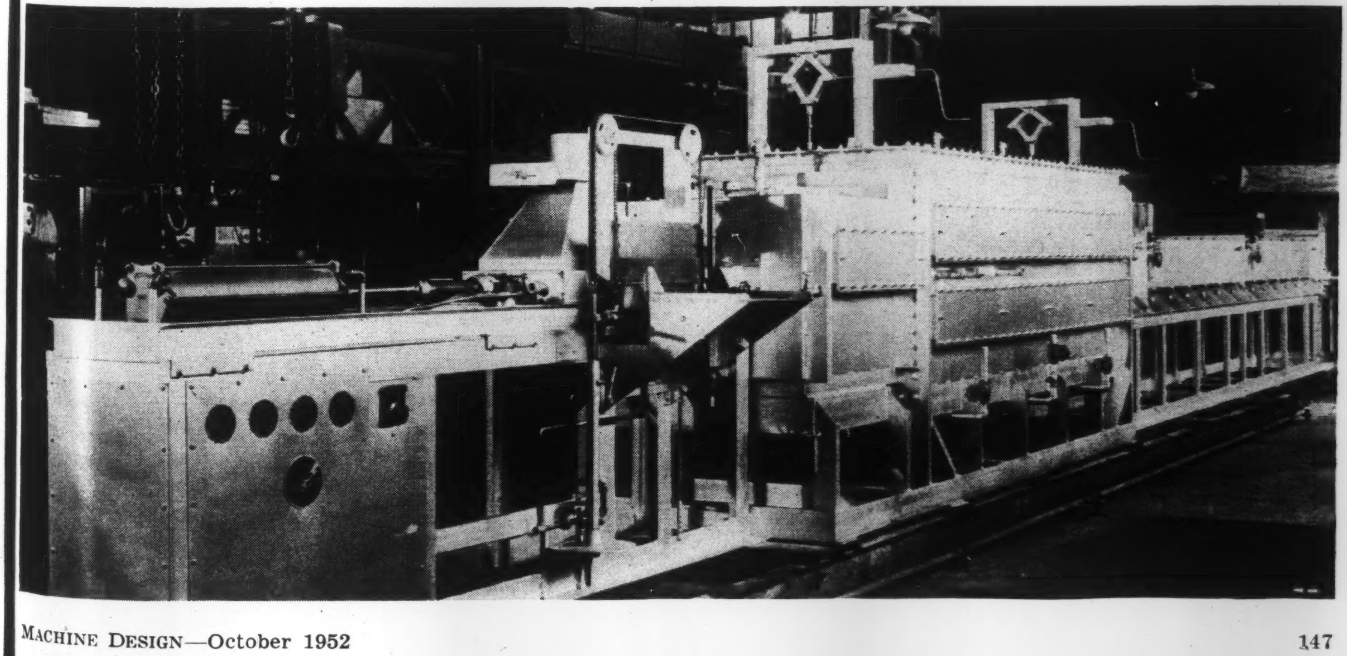
Machinability has always been a problem with steel sinterings but it is being constantly improved as greater knowledge is obtained. Sinterings are being produced today with good machinability but since they are neither steel nor cast iron, conventional practices must be revised to suit the individual characteristics of the sintered part. Normally, the average part can be machined better if the density is not too high and the part is well sintered.

Nonferrous alloy powders are also being extensively used. Those containing zinc, such as brass, nickel silver, etc., are finding large-volume use for hardware and military fuse parts particularly. Sintering of parts containing zinc is difficult because of zinc's low vaporization temperature which is less than the required sintering temperature of 1500 F to 1700 F. However, producers have developed various techniques for overcoming this problem and are producing uniformly strong parts.

Nickel silver (64 per cent copper, 18 zinc, 8 nickel) has found several new uses because it is a relatively low-cost corrosion-resistant metal that looks like silver and can be polished to an excellent finish. Aluminum bronze has been investigated and promises to find many applications for a hard nonferrous material.

Pure aluminum and some aluminum alloys have been produced and show considerable promise. The real problem with these materials is their great affinity for the tools in which they are pressed and the resulting galling. New methods of lubrication to prevent this galling have been developed and are proving successful to some extent. An interesting feature of sintered aluminum is that its density can be 100

Fig. 16 — Large Harper continuous sintering furnace. Such installations are giving improved control of the critical sintering operation as well as speeding production

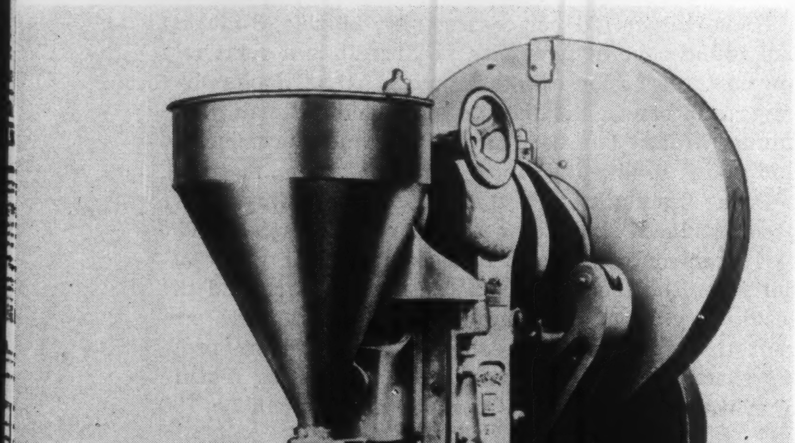


per cent because of the extreme malleability of the powder. Solid metal density results with pressures of 40 to 50 tons per square inch and physical properties are commensurately high.

With normal brasses and bronzes, tensile strength of 20,000 to 45,000 psi can now be realized according to alloy and density. Ductility is good, with elongations ranging as high as 20 or 30 per cent for some materials.

Finishing: Application of finishes to sinterings is often troublesome because of their inherent porosity. That is, electrolytes and cleaners used in plating operations impregnate the structure and cause internal chemical action which continues indefinitely. To overcome this difficulty, a number of special techniques have been developed for successfully plating both ferrous and nonferrous parts with coatings of the usual protective or decorative metals.

Fig. 17—Modern briquetting press for forming compacts at high rate of speed. Equipped with hydraulic overload release, this double-action Stokes press has a 25-ton capacity



Steel parts have been blackened by dip methods and by steam treatment. Also, with some special care they are being porcelain enameled, dip and spray painted, galvanized, and tinned.

Methods and Equipment: Production techniques have continued to improve as the industry has grown in recent years. One example relates to the production of gears. Accurate gear tools with 10 times the life and lower cost than 12 years ago can now be obtained because of developments in an allied powder metallurgy field—sintered carbides. Carbide shapes hot pressed in graphite form dies become the die liners for actual gear pressing after very little finishing work.

Specialized equipment developed for the industry is coming into use, with resulting increased rate and uniformity of production. Parts up to 100 pounds can be made. Continuous furnaces as long as 100 feet are being used to decrease the cost of sintering. A large continuous installation is shown in *Fig.* 16. Similarly, briquetting presses, *Fig.* 17, for forming compacts at high rates of speed have been developed for the industry.

Design: Tolerances possible without special techniques are gradually narrowing. Some parts are being produced with 0.001 to 0.002-inch per inch cross-sectional variation and 0.002 to 0.005-inch per inch axially. An eccentricity limit of 0.001-inch full indicator reading is being maintained on other parts by special setups.

Quality and producibility of sinterings are affected by innate characteristics of the process and the degree to which they are recognized in design. For example, physical properties of the final part are governed by the density of the part. Pressures ranging from 40,000 to 150,000 psi are commonly employed. But since powders tend to follow the rules of solid flow rather than fluid flow, even extremely high pressures will not assure high density if the design does not allow for such flow characteristics.

It is being increasingly found that greater advantage can be realized with the process if efforts are made toward simplicity of shape in the finished part. Inspection, tool maintenance and other factors are correspondingly minimized.

Although die design and construction have advanced in recent years, certain fundamental principles remain unaltered. Part design calling for split dies should be revised if at all possible. Split dies are difficult or impossible to operate because of the high pressure involved, and the infiltration and compression of powders between the die segments.

The Future: The feeling among those familiar with the current status of the powder metallurgy industry is that the surface is barely scratched. Experimental work is being done on many large-volume parts such as piston rings, commutator segments and refrigeration compressor elements. Processes such as the direct production of thin sheet and strip from powdered ore products are developing and hold out intriguing possibilities in design.

Perhaps one of most significant aspects for future benefits is the character of the process permitting the production of many new combinations of alloys and materials. Powder techniques can combine metals and nonmetals, easily produce alloys that are difficult or impossible to cast, and combine liquids and metals.

In general, all physical properties of various metal sinterings will increase as more and more experimental work is done. It is well within the realm of the probable that tensile strengths in hardened steel sinterings will reach 200,000 psi on a production basis before long.

Lower costs can be expected as greater knowledge leads to better and faster presses and furnaces and decreased need for secondary operations. Tolerances on parts as taken from the sintering furnace will continue to close in as increased work is done on the exact control of the powders and the sintering operation. The upper limit on size of parts will increase as a natural evolutionary process.

PLASTICS

John Delmonte

Consulting Engineer, is author of three texts on plastics and adhesives, and is one of the most articulate exponents of plastics in general engineering. Here he briefs a few of the recent plastics developments significant in design.

NEW types of plastic materials and new manufacturing techniques have been combined in recent years to enable designers to exercise greater latitude in material selection. Parts of larger size, higher impact strength, greater heat resistance or other qualities measuring up to higher engineering requirements feature these trends. Gains registered by plastics appear from many directions. In this discussion, a brief survey is made of some of the more impressive materials and techniques.

Several basically new plastic materials have appeared on the horizon in recent years. Among these are the silicones, alkyds, nylon, fluorinated polymers, and epoxy resins. Although some of these, such as the silicones, nylon and the alkyds, have been available for a number of years, they are being increasingly adopted by designers with noteworthy results.

Silicones as coatings, as both lubricants and rubberlike compounds for high and low temperatures, and as high-temperature insulation have been unique in the engineering field. Mineral-filled alkyds, capable of molding cycles of less than 30 seconds, are serving the mass production of electrical and mechanical components. Heat resistance, arc resistance, and low electrical loss at high frequency have engendered significant engineering applications. Nylon's application to gears, bearings, and other mechanical components continues to grow in importance and volume. Toughness, resiliency, and low coefficient of friction are responsible for many of nylon's growing engineering uses.

Fluorinated Polymers: Probably the newest of the plastics to attract design interest is the group of fluorinated polymers known as Teflon (tetrafluorethylene) and Kel-F (trifluorochloroethylene). Possessing exceptional heat resistance and outstanding chemical resistance, the fluorinated polymers open an entirely new phase of the plastics industry. The fluorinated polymer, with the carbon to carbon linkages assiduously protected by fluorine atoms, is strictly a thermoplastic material, though a thermoplastic which will withstand operating temperatures higher than most thermosetting compounds.

For parts requiring a relatively high degree of flexibility or resiliency at higher than usual safe temperatures for plastics, there were no acceptable materials until the advent of the silicones and the more recent fluorinated polymers. Toughness of the fluorinated derivatives has made them popular in the design of packings and O-rings where operation up to 500 F may be encountered. Bearings of fluorinated polymers, which possess low coefficients of friction, are also being increasingly applied.

The outstanding chemical resistance of fluorinated polymers influences their selection in certain specialized directions: for example, in the metering and the control of chemicals such as fuming nitric acid used in some liquid propellant type of rockets. Resilient materials for sealing and control purposes in such applications are limited to the fluorinated polymers which are chemically inert to all concentrations of acids, including hot aqua regia.

An important consideration in dealing with the fluorinated polymers is the physical shape of the material. There are several, including films of various thicknesses, granules for molding and sintering purposes, rods for machining and aqueous suspensoids for coating.

Table 3—Properties of Fluorinated Polymers

Property	Tetrafluoroethylene (Teflon)	Monochlorotrifluoroethylene (Kel-F)
Specific gravity	2.2	2.1
Tensile strength (psi)	1800	5700
Modulus of elasticity (psi)	58,000	190,000
Elongation (per cent)	110	28
Heat resistance (Continuous F)	500	390

The most widely used form is the film which may be die cut into various gaskets or employed for high temperature insulation of coils. Molding is conducted with greater difficulty, and a sintering operation is generally necessary to achieve complete fusion of Teflon products. Greater ease of molding is experienced with Kel-F which does not possess quite as high a temperature resistance as the completely fluorinated polymer. *Fig.* 18 shows typical molded and machined members of the fluorinated polymers. Other applications are developing about coated glass fabrics and tapes.

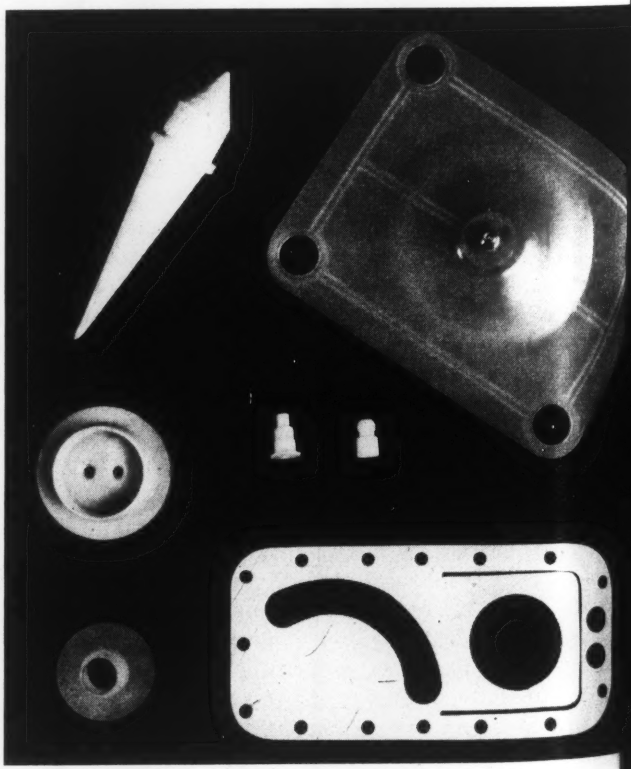
The suspensoids offer one method for applying coatings of fluorinated polymers. Because the water phase must be evaporated, only a thin coating may be applied at a time and then fused at high temperature before the next layer is applied—a long and costly process. Sheets of steel have been Teflon coated in this fashion but their cost has been prohibitive. The basic fluorinated plastics themselves are expensive, averaging $10 to $15 per pound. However, because of the unique qualities offered by these materials, this price is proving to be no deterrent in critical applications. Typical properties of the fluorinated polymers are listed in TABLE 3.

Epoxy Resins: Still a relatively new name to most designers, the epoxy resins are now manufactured by several major suppliers in this country. The resins are well known in some fields for their outstanding adhesive properties. Manufacturers of brake linings and clutch facings have found them well adapted to the replacement of riveted assemblies. Of course, other compounds such as phenolic-rubbers and phenolic-vinyls also offer good bonding qualities. However, the epoxy resins alone bond to metal at low temperatures. This favorable quality is leading to their growing use for bonding assemblies. Epoxy adhesives are also effective in bonding widely different materials to one another. For example, in *Fig.* 19 is illustrated a tension compensating device in which sapphire parts are bonded to metal.

Casting and potting of epoxy resins are on the upswing. Although the potentialities of these highly useful materials are not fully recognized as yet, they have made many successful entries into industrial applications. Cast epoxy resins are now available in a range of physical properties—from hard rigid grades to soft resilient types.

Rubber Phenolics: General rigidness and shock resistance of plastic components are being improved by the use of combination materials. This trend,

Fig. 18—Molded and machined fluorinated polymer parts. Photo, courtesy W. Shamban and Co.



originated long ago in the paper and fabric reinforced laminated phenolics, has taken diverse forms.

The mainstay of compression-molded plastics, the phenolics, has been improved in impact strength by another variation of this technique. Blends of rubber and phenolics have been developed with shock resistant qualities much superior to the basic resin alone. Designs calling for maximum toughness can usually sacrifice some tensile strength in return for the greater resilience resulting with an also lower modulus of elasticity.

High-Impact Polystyrene: Another material offering improved impact strength is polystyrene. For many years polystyrene has offered good moldability, coupled with qualities that have made it attractive for many mass-produced consumer articles. Its outstanding electrical properties and low moisture absorption have motivated important engineering applications, particularly on electrical equipment. However, the lack of adequate heat resistance and mechanical strength—particularly in impact — have deterred its more widespread adoption. Recent developments in modified styrenes, referred to as high impact polystyrene, give promise of opening new applications for this versatile plastic. Slightly higher cost and not as high a gloss may be considerations in appraising high-impact polystyrene for engineering use.

Other Rubber Plastics: Styrene-butadiene copolymers have been identified in the synthetic rubbers since the start of World War II. However, the major component in this instance has been butadiene and the end products have been rubber like. In planning improved impact qualities, research workers have been cognizant of the fact that in sacrificing tensile strength for greater elongation—that is to say, working towards more rubberlike characteristics—higher impact strength is realized. It is not unexpected then to find that high styrene-butadiene copolymers, with styrene as the major component, have been incorporated in certain tough molding compositions of particular interest to machine designers. In general, these compounds, available from various producers in different grades, are identified as "mixtures of resins and rubbers," and usually contain some butadiene-styrene and acrylonitrile polymer.

These materials are available both as molding compounds and in various other forms. For example, one type can be obtained in various colored sheets with flat or textured surface. Sheets can be drawn and formed into quite complicated shapes. One well known component is the framing plate for television lens. Another compound prepared from the addition of small amounts of synthetic rubber to high styrene copolymer resins can be compression molded for parts requiring impact and water resistance.

Resins with Glass Fiber: Materials and techniques of low-pressure, reinforced plastics molding have been brought to the fore in recent years by the use of polyester resins with glass fibers for structural units ranging from one-piece boat hulls or automobile body assemblies to small electrical insulating units.

The design of machines has already been influenced in many ways by polyester resins and glass fiber. One major manufacturer of washing machines has designed and successfully produced the important structural components in glass-reinforced plastic. Others specialize in molding resin and glass fiber combinations into numerous mechanical and electrical components. For example, a new polyester-glass fiber molding compound is finding its way into adding machine housings, camera housings, and pump rotors. In general, materials of this description can be molded

Fig. 19 — Tension compensator manufactured by Walter Kidde Co. with two sapphire parts bonded to metal with epoxy adhesive. Photo, courtesy Ciba Co.

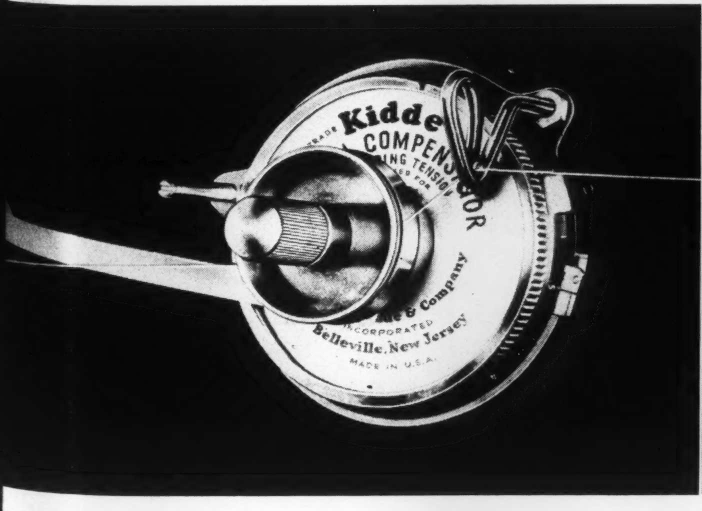
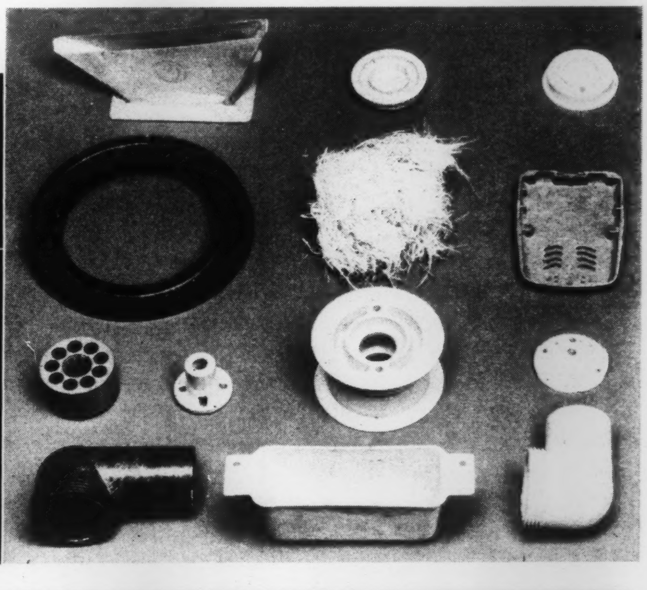


Fig. 20—Parts molded from resins combined with glass fiber (sample shown upper center). Photo courtesy Flex Firm Products Co.



at ¼ to ½ of conventional molding pressure.

In one sense, glass fiber-reinforced resins open latent design possibilities by making possible large structural components at lower tool cost than required by conventional molding methods. On the other hand, resin-glass combinations are proposed as substitutes for other high-impact molding compounds, where chemical inertness, superior impact resistance of glass fibers, or lower molding pressures may be utilized to advantage. *Fig.* 20 shows an assortment of typical small glass-fiber reinforced components.

Potting: The term "potting" is heard more frequently in connection with electrical components, although there are features present with which machine designers should become familiar. In the potting of electrical assemblies, the grouping of insulators, vacuum tubes, condensers, resistors, coils, etc., are completely imbedded in a liquid plastic, which hardens on cooling or by chemical processes. Three important advantages accrue: Impact qualities of the integrated assembly are enhanced, moisture protection is assured, and the heat dissipation features are improved.

Epoxy resins, polyesters, furanes, and vinyl resins have been utilized in potting components and would serve adequately in the protection of mechanical or electrical components. The complete encasement of small units in a solid plastic is fraught with numerous problems, although considerable experience in this direction has been accumulated in the electronics industry. Shrinkage and difference in thermal expansion must be considered carefully.

Vinyl Foam: Designers accustomed to thinking in terms of natural or synthetic rubber foam will now find a new plastic foam comparable in texture. The new material, prepared from vinyl plastisols, possesses superior flame resistance, chemical resistance, and ease of fabrication. The foam is formed with the aid of gas pressure and may be utilized to fill molds to produce rubberlike products. Oils or greases which may adversely affect rubber compounds do not affect the vinyl foam.

Future: An intriguing aspect of the plastics industry is its ability to create new materials of construction out of seemingly impotent chemicals. There is no telling in what guise they will appear next, but the designer keeping informed of their qualities will detail significant engineering applications.

ALUMINUM ALLOYS

John R. Willard

Mgr., Sales Development Div., Alcoa, reports on a few of the factors that have recently influenced aluminum's growing stature in the mechanical product field. His 26 years of activity in the industry has included development work on innumerable products in the equipment, consumer goods, and military fields.

TWO fundamental reasons account for aluminum's increasing importance to design engineers. First, aluminum is gaining an attractive price advantage in many instances. Secondly, new equipment and new processes for the manufacture of aluminum have opened up many new uses and in many cases reduced intermediate fabrication costs.

Aluminum sells today for 5 per cent less than it did in 1939. Copper is up 118 per cent; pig iron is up 147 per cent. The price of lead has nearly doubled and the price of zinc has come close to being tripled. Of importance also are the new equipment and processes which have loomed into the design picture during the past year. They run the industrial gamut: forging, extrusion (hydraulic and impact), casting (sand, permanent mold, plaster, and die), rolling, joining, finishes.

New Equipment: Two pieces of equipment are so new that it is still difficult to evaluate accurately their significance. At Alcoa's Lafayette (Ind.) Works a giant 13,200-ton extrusion press is being installed to produce extruded shapes in previously unheard of sizes. In order to straighten these "king-size" extrusions a new stretcher with a pulling force of 3,000,000 pounds is required. With the new extrusion press Lafayette will be able to nearly quadruple the weight of its extrusions from 600 pounds per piece to 2300 pounds. While maximum length of extrusions remains at 90 feet, the sizes which can be produced in that length increase from 6.7 pounds per foot of length to 25.5 pounds, or from 5.6 square inches in cross sectional area to 21.3 square inches. Maximum circumscribing circle diameter for shapes may increase from the present 14 inches to 23 inches.

In terms of products the new press means wider, lighter, more intricate shapes for such things as ribbed airplane wing panels, truck panels and floors, sections for thin-wall building construction, 20-inch pipe where the previous outside diameter limit was 12 inches. These potential products will be the result of the press being 2½ times as powerful as any extrusion press now in operation in the country.

Another new piece of equipment, now actually in operation at Alcoa's Cleveland Works, is a 15,000-ton forge press valued with auxiliaries at $6,200,000. The press, *Fig.* 21, is particularly well adapted to the production of forgings made from aluminum-base alloys with a high magnesium content and magnesium base alloys because these alloys must be formed with the slow, heavy pressure obtainable only with hydraulic presses. In some instances the press dies, made by a huge double-headed die-sinking machine especially installed for the job, will weigh up to 25 tons. Since the dies are subjected only to forming and flow pressures their life will be increased 100 to 600 per cent. The new press is part of a $13,200,000 expansion program to enlarge Alcoa's 35-year old Cleveland Forge Plant, already the largest aluminum forging operation in the nation. Simultaneously, Alcoa has been producing individual experimental ingots weighing upward of 10,000 pounds each, and methods of control of metal quality have been improved, including the adoption of the rapid vacuum test for measuring gas porosity.

New Processes: Paralleling the dynamic expansion of the industry and the installation of new equipment by Alcoa has been the work of engineers who have modified old processes and developed new ones.

Last year one of the outstanding impact extrusion developments was the cold working of high-strength alloys to make such parts as landing gear strut supports. This process not only saved considerable metal but also worked added strength qualities into the product. During the same period of time closer tolerances were achieved in impact extrusions. Formerly plus or minus 1/32-inch was considered extremely good. Today coining tolerances of plus or minus 0.005-inch on particular applications are being maintained. In addition to these developments, the ratio of length to diameter in impact extrusions has been extended from 7 to 1 to 16 to 1.

At the moment, a new brazing process has made aluminum cylinder blocks, heads and crankcases some of the most attractive actual and potential applications of aluminum in the automotive market. The trick of the new brazing process lies in a sandwich type of construction in which three or four sections are cast separately and then piled on top of each other with a thin brazing sheet between them, *Figs.* 22 and 23. When put into a high-temperature furnace, the brazing sheet melts at a lower temperature than the separate pieces and results in a final one-piece cylinder head or block. The process looks good because it eliminates much core work and machining. As one result, the use of aluminum in cylinder heads is expected to quadruple to 23,400,000 pounds by 1954. Cylinder blocks, which weren't made of aluminum in 1950, are expected to consume about 19,500,000 pounds.

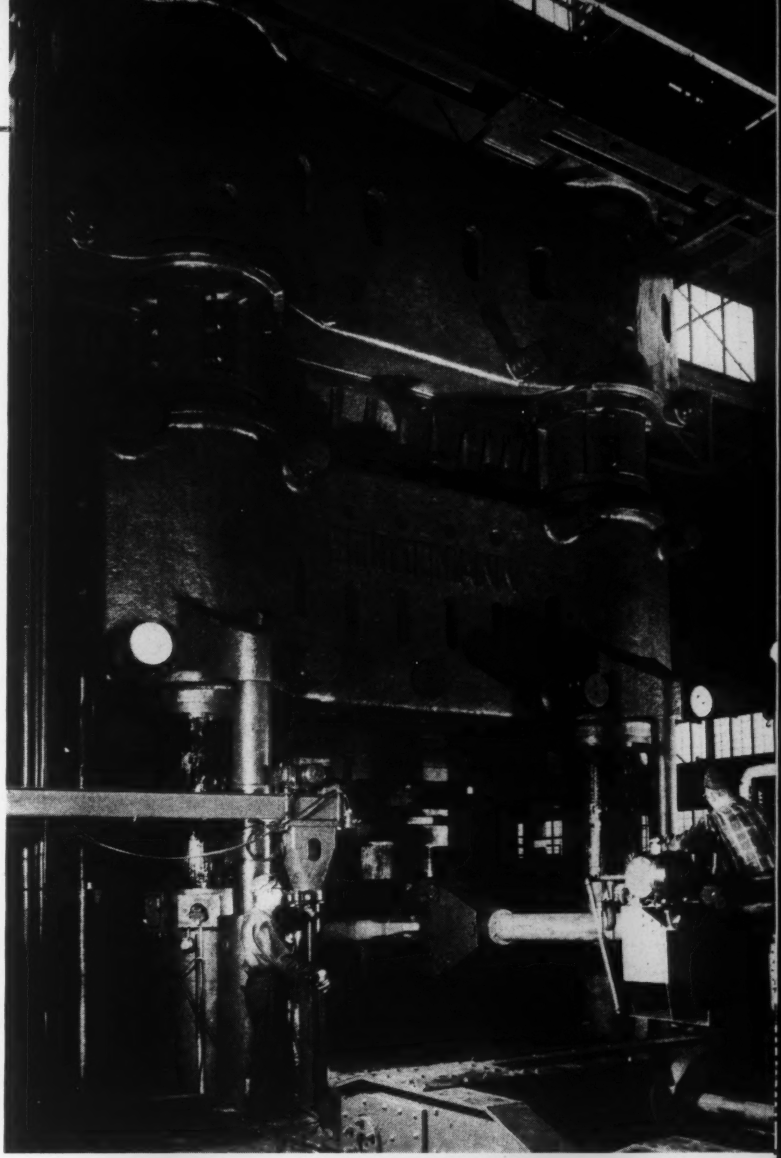


Fig. 21—New 15,000-metric-ton forging press recently placed in operation by Alcoa. Preheated aluminum or magnesium stock is inserted in the press by a large mechanical manipulator

Recently Alcoa started to produce large quantities of pressed structural channels for cross-member floor support in truck trailers. The advantage of the channel pressed from sheet or plate over a rolled or extruded product is that the depth of each individual member may vary. If the total stress is greatest in the center, the member can be made deeper in the center than at the ends and thereby save weight and money.

New finishes, too, have been developed for many uses, and Alcoa is now prepared to produce Alumilite hard coatings with exceptional resistance to wear and abrasion. These Alumilite coatings are in a thickness range of 0.001 to 0.002-inch and may be applied to both wrought and cast aluminum alloys. The new wear-resistant Alumilite finish is being evaluated for gun blast tubes, gears and impellers and similar applications where resistance to abrasion is required in combination with light weight.

Joining problems have been under intense development work for a number of years and, as already indicated in the brazed cylinder block, the results of this work have been paying off. Just recently Alcoa modified a German technique for welding small diameter aluminum wire so that simple equipment operated by batteries can now be used for making small wire connections. There has also been a marked trend away from the use of steel rivets in aluminum alloys construction in a wide variety of applications. A notable example is the transatlantic superliner, S. S. United States, in which are used aluminum alloy rivets in sizes ranging from 3/8 to 3/4-inch. All of these rivets were driven cold. The rivets were heat-treated, quenched and refrigerated, thus arresting the age-hardening process and keeping the rivets soft until driven. Once driven, the rivets hardened in place to permit development of full shear strength.

New Products: One of Alcoa's latest developments has been the production of a new brazing sheet which should find use in automotive radiator work and which, upon investigation, may prove a boon to many other applications of aluminum.

The new product, called No. XA30 Brazing Sheet, has a core metal of 3S alloy. One side of the core metal is clad with C43S brazing alloy to assure good joints, and the other side has an alclad coating which offers electrolytic protection against the corrosive action of water which is used in certain areas of the country in radiators. The importance of the new development is pointed up by the current and predicted long-range shortage of copper which is consumed at about the rate of 20 to 25 pounds per standard passenger car radiator.

Alcoa Utilitube is another product which was marketed for the first time last year. A general purpose tube of Alcoa alloy B50S-O, the new tubing is suitable for use in oil, gasoline and lubricating lines to engines; fuel lines to heaters; and air, hydraulic and vacuum lines to brakes and instruments. It will also handle kerosene, cutting compounds and most refrigerants. Flaring and forming characteristics of the

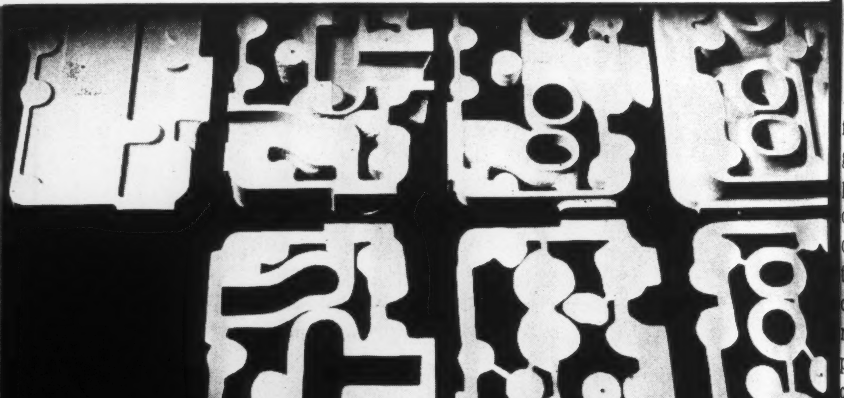


Fig. 22—Four sectional slices of an aluminum cylinder head after being cast by the permanent-mold process. Lower parts are stamped aluminum brazing gaskets which are placed between the slices

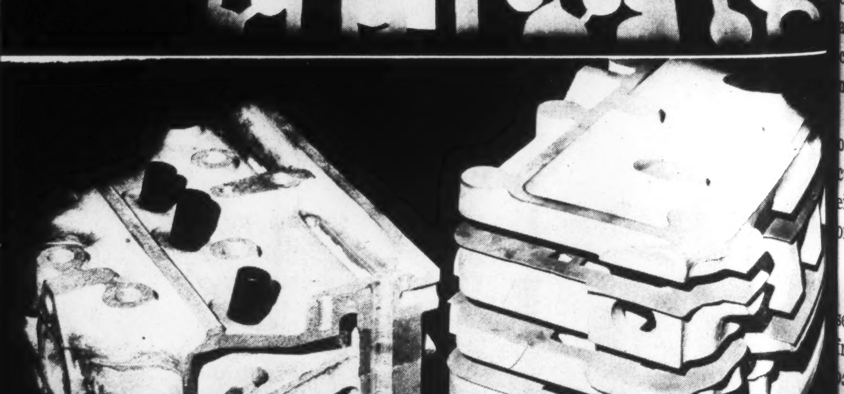


Fig. 23—Section of the aluminum cylinder head as it appears after the brazing operation, and a slightly exploded view of the slices and aluminum filler gaskets

tubing are good. The new tubing comes in coils up to 1000 feet in length and in sizes between $\frac{1}{8}$ and $\frac{3}{4}$-inch. The price is substantially less per foot than the price of copper.

A new aluminum alloy, temporarily designated XA78S, has resulted from several years' co-operation between Alcoa, the Navy Department Bureau of Aeronautics, the U. S. Air Force and the aircraft industry. The new alloy is stronger than any alloy previously made available. It is 10 per cent higher in tensile and yield strengths than alloy 75S but has about the same elongation and fatigue properties. So far, use of XA78S has been confined to production of extrusions, sheet and plate, both bare and alclad.

CORROSION-RESISTANT MATERIALS

Howard T. Francis

Supervisor, Electrochemistry Sect., Armour Research Foundation, defines the corrosion problem and highlights preventive measures. Dr. Francis is active in professional societies in this field and is author of a number of papers contributing to the knowledge of this destructive phenomenon and its circumvention.

IN THIS age of specialization, the design engineer might be likened to a general practitioner in the field of medicine—he must know something about a great many things. Not the least of the designer's problems is: What should it be made of? Of course, on problems beyond his normal experience he can consult tables of strength, weight, electrical conductivity, frictional properties, etc. When it comes to corrosion resistance, however, the problem of material selection becomes more complicated. The expected conditions of exposure, the desired appearance of the part, its life expectancy—all these and more—are tightly bound up with method of manufacture, cost of materials, and the availability of specific metals.

This discussion will deal with the basic philosophy of corrosion and its prevention, outline some of the current practices, and suggest future steps which either appear desirable or are mandatory in the face of the shortages of many metals.

What Is Corrosion? Corrosion, in the broadest sense, is simply the undesirable reversion of a metal from its *metallic* state to its chemically combined or *oxidized* state. Practically all metals have a definite tendency to react with water, oxygen, or other substances to form metallic oxides or salts. The exceptions are the noble metals such as gold and platinum. Rather than ask, then, "What *causes* corrosion?" it is much more pertinent to ask, "What *prevents* corrosion, in the face of the reactivity of metals?" The answer is that a great many metals and alloys form corrosion products which are thin, adherent, chemically inert, and in many cases transparent. This self-protecting behavior is quite dependent on the environment to which the metal is exposed. When it occurs, however, the metal behaves as though it were noble. Surprisingly, this phenomenon is characteristic of many of the most reactive metals and alloys—aluminum, chromium, nickel, titanium, zirconium, stainless steel, monel—and to a lesser extent of copper, silver, magnesium, lead, brass, and bronze.

When it is possible to use a metal having this property of inherent corrosion resistance—taking into account cost, strength, and all other determining factors—one need not worry about corrosion. All that is required is that the metal be exposed only to corrosion media in which its protective layer of corrosion product will not be destroyed.

Unfortunately, several of our most readily available metals do not possess the property just described. Instead of thin, adherent, inert corrosion products, they form bulky, nonadherent, unsightly products which offer little or no protection against continued attack. Ironically, the metal most responsible for our present industrialized civilization is the most sadly lacking of all in its natural resistance to corrosion. Iron and steel, in even the mildest environments, suffer rusting and flaking which make their use impossible without artificial protective measures.

Far less widely used in terms of tonnage, but none the less significant in terms of low cost and ease of fabrication, are the zinc-base die-casting alloys. They too suffer serious corrosion in any but the mildest exposure, making artificial protection imperative.

Corrosion Prevention Principles: The methods of preventing corrosion in metallic structures can be classified according to several distinct basic principles, as follows:

1. *Isolation of the metal from the corrosion medium.* This is by far the commonest device employed, and includes (a) the use of inherently self-protecting metals; (b) the use of relatively thin coatings of a corrosion-resistant metal (frequently applied by electroplating); and (c) the application of inorganic or organic protective coatings.

The inorganic coatings are exemplified by the anodizing of aluminum, *Fig.* 24, the Bonderizing of steel, and the newly announced HAE process for magnesium. The organic coatings include a vast number of lacquers, paints, plastics, and similar products which are too numerous and complex to include in this discussion; they will be called "paints" for simplicity.

2. *Sacrificial protection by a metallic coating.* This technique is used principally where appearance is secondary to protection of the base metal. Since many millions of tons of steel are protected in this way, however, its importance should be recognized. The inside surface of the ordinary tin can depends on the sacrificial attack of tin by food products to protect the thin steel body from perforation. Galvanized pipe, fence wire, outdoor electrical hardware, and many similar items make use of the greater reactivity of zinc to prevent rusting of iron and steel.

3. *Modification of the corrosive environment.* Under this heading are lumped the use of corrosion inhibitors, cathodic protection, and all the other devices used by corrosion engineers to lessen the potency of the corrosion medium itself. Since these techniques truly belong to a specialized field, the designer can hardly be expected to specify their use except with the close co-operation of the corrosion engineer. Therefore, no attempt will be made to expand on this phase of corrosion prevention.

Evaluation of Preventive Measures: From the foregoing outline, it is apparent that the designer is concerned primarily with the first item, the corrosion-preventive techniques which isolate the metal in question from the environment in which it must serve. Briefly the advantages and disadvantages of each of these basic approaches can be compared.

Self protection. Manufacture of a machine or structure from a metal which has inherent corrosion resistance is undoubtedly the most satisfactory practice when viewed solely from a corrosion-preventive angle. Damage to the surface by abrasion or handling does not usually cause acceleration of corrosion. The freshly exposed metal immediately forms a new corrosion-product film, which protects against further attack.

Unfortunately, most of the metals which have excellent self-protecting qualities are costly, scarce, or lacking in desirable physical properties. The stainless steels, the nickel alloys, copper and its alloys, chromium, and many of the less plentiful metals such

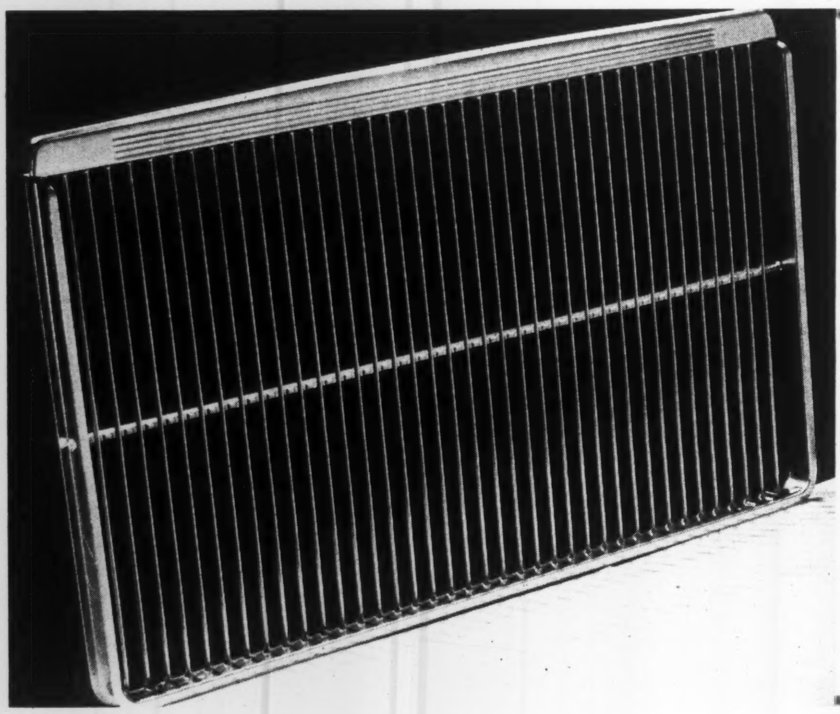


Fig. 24—Refrigerator shelf of anodized aluminum, an example of an inorganic protective coating. Photo, courtesy General Electric Co. and Alcoa

as tantalum, zirconium, gold, silver, platinum, molybdenum, and tungsten, are far too scarce or costly to justify their use for any but the most demanding conditions of exposure. It is neither economical nor wise to use these metals when others will function equally well.

On the other side of the ledger are several self-protecting metals which are relatively plentiful and promise wide utility as their technology continues to advance. The most important of these is, of course, aluminum. Its combination of physical properties and corrosion resistance has already given it almost exclusive use in the aircraft industry. It is to be expected that, as the cost differential between aluminum and (protected) steel continues to diminish, aluminum will see ever-increasing use, *Fig.* 25.

A second metal, which is available in unlimited quantities, is magnesium. Although its self-protecting properties are not nearly as satisfactory as those of aluminum, there are many applications where the environment is so mild that magnesium can be used without further protection. The HAE process for producing a tightly adherent and truly protective coating on magnesium promises to give magnesium a tremendous boost in general utility.

To delve for a moment into future possibilities—one of the most widely hailed new developments is the Cinderella metal, titanium. While it is difficult to predict the time which will be required for its large-scale, low-cost production, it can be safely stated that it will be a high tonnage contribution to the inherently corrosion-resistant class of metals. It is practically unaffected by exposure to all atmospheric conditions—even salt water exposure causes negligible corrosion on titanium.

Artificial protection by metallic coatings and paints. By far the largest proportion of our metallic machines and structures are iron or steel. The discussion of artificial protection by various means will therefore be directed primarily to these materials, with the understanding that die-cast metals and other readily corroded alloys demand similar protection.

Perhaps the most common practice in protective metallic finishing of steel is the familiar copper-nickel-chromium system. After suitable buffing, cleaning, and pickling, the steel article is electroplated with relatively heavy layers of copper and nickel, then flashed with a few millionths of an inch of chromium.

Although this technique was fairly satisfactory in past years, the cost and shortage of both nickel and copper have forced a gradual lowering of the thickness of nickel and copper to a point where the protection derived from such coatings is often far from ideal. Probably the largest single field in which copper-nickel-chromium finishes are used is the automotive industry. Everyone is familar with the rapid failure of door-handles, bumpers, and trim used on modern cars.

It is this field of artificial protection which appears most in need of some basic changes—both from the design standpoint and from the consumer-demand point of view. When looked at strictly from the corrosion-prevention and metal-conservation angle, present practice is doomed. Every reduction in plating thickness which is made (to save metal) results in a further lowering of the corrosion protection achieved—which is, after all, the primary objective.

True, other metals and alloys can be used in coating form to protect the base metal. Heavy pore-free

Fig. 25—Bus showing aluminum application in the front bumper as well as in body panels. Corrosion resistance is combined with strength and light weight. Photo, courtesy Alcoa

tin coatings would give excellent protection to steel in atmospheric exposure. Its scarcity, however, precludes such use. Heavy brass or copper coatings would give very good protection to steel, even in fairly severe conditions. Here again, cost and supply make the use of these metals impossible in the thicknesses which would be required. Lead coatings are frequently used to protect steel; here the cost and supply are not as serious, but the appearance and softness of a lead surface discourage its use in many cases. Cadimum is one of the commonly used plating metals which functions in part as a covering metal and partly as a sacrificial coating. Its appearance is better than that of zinc, but cost is prohibitive.

Hence, as far as protective metal coatings are concerned, an impasse has been reached. One might ask, "Why not plate heavy coatings of one of the cheap, plentiful, self-protecting metals, such as aluminum or titanium?" This would indeed be a wonderful solution to the problem, and it would be very unimaginative to say that such processes are impossible. At the present time, however, such electroplating techniques appear fairly improbable. The great reactivity of aluminum and titanium makes their reduction to metal from aqueous solutions quite unlikely.

The possibility of hot-dip coating of molten aluminum onto iron and steel is quite another story, however. It is being done currently, and promises to become a major protective technique of the future. Development of a similar titanium coating technique, on the other hand, is extremely unlikely. The melting point of titanium is well above that of any metal upon which one might desire such a coating.

Aside from the hot-dip application of aluminum coatings, no striking new solution to the problem of protective metal coatings can be visualized. Nonmetallic coatings appear much more promising.

As stated earlier, this article will not attempt to describe or recommend specific paint coatings for metal protection. But innumerable new developments in this field might be pointed out—new plastic combinations which offer corrosion protection far beyond that attainable with even a heavy electroplated metal coating. It is for the designer to gradually wean the public mind away from the well-sold impression that metal articles must be bright and shiny to be high-quality. For example, is it not conceivable that future automobiles might desert the brilliance of chromium, which has reigned for the past twenty-five years? If we don't make the transition gracefully, we will be forced to accept cars whose bright finishes will rust even before the dealer receives them! It should be possible to utilize baked enamel finishes to produce equally attractive artistic styling which would have far greater useful life, *Fig.* 26.

Teamwork: To summarize, the complexity of many corrosion problems might first be emphasized. This discussion has dealt chiefly with normal indoor or atmospheric exposures—those that can be treated in fairly general terms. For the specific exposures encountered in the design of chemical processing equipment, however, the designer should feel perfectly justified in not attempting to treat the case alone; he should consult the "specialist," the corrosion engineer. Such teamwork will insure against costly errors which might waste otherwise valuable design effort.

Certainly, the corrosion specialist will frequently have to admit that he cannot answer a specific question on material selection without further test data. But on many everyday problems, he can narrow the choice of possible metals to those which will serve in the particular environment expected.

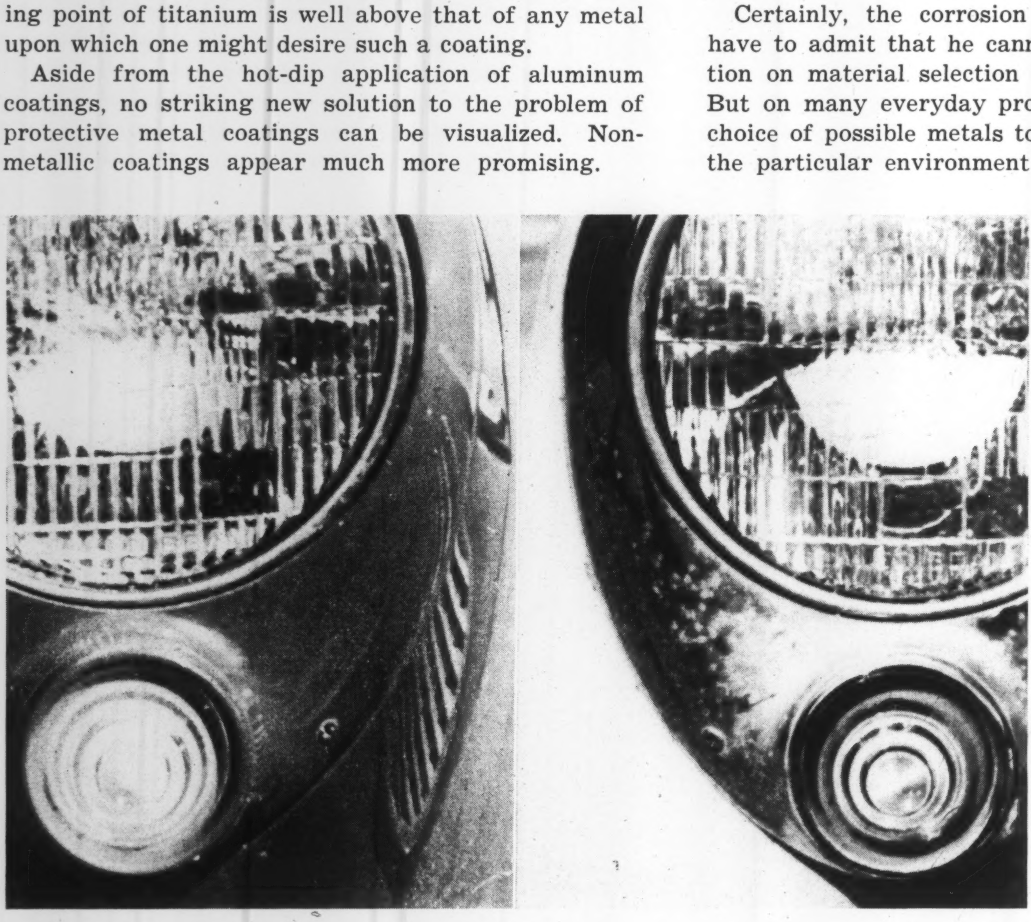


Fig. 26—Plating versus e
amel on identical headlig
rims. Enameled rim co
less and lasts longer

HEAT-RESISTANT ALLOYS

Roger A. Long

Chief, Metallurgical Branch, Lewis Flight Propulsion Lab., NACA, summarizes alloys used in high-temperature service, drawing from his experience in dealing with problems involved in the fabrication and development of materials for gas turbines, ram jets and rockets.

CONTINUING development of the jet engine intensified the demand for knowledge of materials for high-temperature applications. The use of materials for higher temperatures was first initiated during and after World War I by the chemical and related industries, where steam pipe temperatures were being driven higher by the demand upon the industry. Turbosupercharger development before and during World War II further increased the necessary working temperature of the alloys beyond that of alloy steels into a field of austenitic type stainless steels containing increasing amounts of additional elements. A number of these stainless type steels are given in TABLE 4. The last-listed alloy, Timken 16-25-6 was widely used during the last war for turbosupercharger disks and even today is being widely used for this part of many turbine rotors.

The first American turbojet engine, the General Electric Co. I-16, utilized a Haynes Stellite nickel-base alloy designated Hastalloy B for the rotor buckets. This alloy had a rupture strength exceeding any known material at that time—10,600 psi for 1000-hour life at 1500 F. However, since it is a forged alloy and because of lack of forging capacity, it was imperative that other methods of fabrication be found for the newer type turbines then being designed.

Haynes Stellite No. 21 alloy, a modification of a cobalt-base alloy already used in the dental and surgical fields, was also investigated. Cobalt-base alloys had been well known for their hot hardness and were therefore a logical choice for further development studies. Haynes Stellite No. 21 had good oxidation and corrosion resistance and could be precision cast. The high-temperature rupture strength of the modified alloy was found to be excellent, exceeding any known material at that time—1000-hour rupture strength at 1200 F of 44,000 psi and at 1500 F of 15,000 psi. From a designer's standpoint it was an excellent material for gas turbine rotor blades.

Table 4—Stainless Type Heat-Resistant Alloy

Material	Composition (per cent)					Rupture Strength (psi, 1000-hours at 1200 F)
	Cr	Ni	Mo	Fe	W	
Stainless 18-8	18	8	..	74	..	12,000
Timken 16-13-3	16	13	3	66	..	25,000
17 W	13	19.5	0.6	63	3	23,000-34,000
Timken 16-25-6	16	25	6	50	..	35,000-40,000

Development since 1940 has opened wide a field for heat-resistant alloys and, in fact, many thousands of alloys were melted, cast or forged and evaluated. Only about 60 of these, however, have been given any consideration and only about eight are now being used in gas turbines, with still another seven or eight being experimentally field tested.

Metal Alloys: One of the best classification methods for high-temperature alloys is according to the fabrication method. Thus, the alloys can be divided into three main classes:

1. Strain-hardened wrought alloys
2. Heat-treated or aged wrought alloys
3. Cast, or cast and heat-treated, alloys.

An example of the first class is the previously mentioned Timken Alloy 16-25-6. Alloys typical of the second class are Haynes Stellite Hastalloy B, and Allegheny Ludlum S-816. Alloys of the third class for high-stress applications include Haynes Stellite No. 21 and 30, and for low-stress applications the older type cast stainless steels, such as 25-12 (25 Cr-12 Ni), 29-9 (29 Cr-9 Ni) and the Nichrome type alloys containing 25 to 65 per cent nickel and 10 to 20 per cent chromium.

The majority of the alloys suggested for highly stressed parts fall in the second class because a wrought alloy can be easily fabricated and then heat treated to give maximum high-temperature properties. Most of the alloys of this class are of nickel or cobalt base with additions of columbium, titanium, aluminum, tungsten and/or molybdenum for obtaining age-hardenable characteristics.

Examples of these alloys, included in TABLE 5, are:

Inconel X: A nickel-base alloy with 16 per cent chromium made age hardenable by additions of some of the previously mentioned elements. It has a 1000-hour, 1500 F rupture strength of 18,500 psi and satisfactory oxidation resistance up to 2200 F

S-816: A cobalt-base alloy with chromium and nickel, and aging elements. It has a 100-hour 1500 F rupture strength of about 19,500 psi

HC N-155: A modified austenitic stainless steel with high cobalt and carbon content (20 per cent) and aging elements. It has a 1000-hour, 1500 F rupture strength of 17,600 psi.

All these alloys can be forged, are solution-treated above 2000 F, and aged or double aged at temperatures ranging from 1300 F to 1550 F for periods up to 24 hours at any one temperature.

Newer developments of wrought type alloys are grades for sheet applications. For example, most of the alloys just listed are obtainable in sheet or plate form. Also, Haynes Stellite No. 25 (cobalt base) is reported to have high room-temperature ductility and good elevated-temperature strength. Therefore, it can be formed into shapes at room temperature and used at high temperatures.

Forming of many of these heat-resistant alloys requires considerably more care than is used for stainless or Inconel alloys, but almost all of them can be formed by either die cooling, interstage annealing or by using combinations of two or three-stage dies. All can be welded by gas, arc or resistance methods, but proper choice of weld rod and use of careful technique are necessities. Other alloys containing less strategic elements have been or are being developed for uses requiring heat resistance, particularly iron-base alloys such as Crucible 422 and AMS 5616. However, development requires time and expense, and even today investigation of alloys initiated ten or twelve years ago is still in progress.

Ceramics and Intermetallics: A newer type of material has been investigated considerably in the last few years and is of a completely different family than the metal alloys already discussed. These are the ceramic and the "intermetallic" family of materials.

Ceramic bodies have received much consideration for high-temperature use. Recent data from the National Bureau of Standards on their 4811 material (high beryllia, BeO; density = 3.0 gm/cc) has shown a 100-hour rupture strength at 1800 F of 17,000 psi. If these data are compared on a strength to weight ratio to those for one of the best cobalt-base alloys (sp. gr. = 8.6 gm/cc) at 1800 F, the ceramic rupture strength value can be increased to 48,600 psi which is four times that of the alloy material. However, ceramic bodies have had poor thermal shock resistance which has deterred their more general use.

Table 5—General Data on Some Heat-Resisting Alloys*

Alloy	Composition (per cent)								Rupture Strength (psi, 1000 hours)		
	Ni	Cr	Co	Mo	W	Fe	Cb	Ti	1200F	1350F	1500F
S-816, forged	20	20	45	3.5	4	bal	4	..	51,000	30,000	19,500
Inconel X, forged	73.5	14.5	..	..	..	.7	1	2.3	61,500	39,000	18,000
N-155 H.C., forged	20	20	20	3	2.2	bal	..	..	45,500	26,000	18,000
K-42B, forged	42	18	22	..	..	13	..	2.6	40,000	26,500	14,000
422-19, cast	16	25	52	6	..	..	..	..	.....	36,000	23,000
6059, cast	33	26	34	6	..	..	..	..	46,000	30,000	18,800
H.S. No. 21, cast	..	28	64	6	..	..	..	..	44,000	27,500	15,000
X-40, cast	10	25	55	..	7	..	..	..	46,000	34,000	23,400

*Heat treatment for the properties listed varies with each alloy. Generally, the treatments are as follows: (1) Forged alloys—solution treat 2000-2300 F, water or air quench, age 1350 to 1500 F 16 to 50 hours; (2) Cast alloys—age 1350-1500 F 50 hours or use as cast.

However, ceramic coatings on nickel or iron-base alloys show considerable promise and in tests have increased metal life of the part twofold or more. These gains have been applicable, however, to sheet metal parts only. Their thermal shock resistance is better than that of a solid body because the coatings are thin. Examples of these are the Solaramic type coatings and NBS A417 coatings, the latter being commercially produced by Ryan Aeronautical Co.

The use of metallic binders with ceramics and/or intermetallics as a base material has caused the formation of a new type material called Cermets or Ceramals. These metal or alloy additions cause an improvement in the thermal shock properties and reduce room-temperature brittleness. It does not necessarily reduce the strength of the body, since in some cases the strength increases. These bodies are fabricated by pressing and sintering or by hot pressing, the methods being similar to those used in the cemented-carbide industry.

Recent published results by Kennametal Inc. on their titanium-carbide nickel-bonded materials show for their grade K152B, a 100-hour stress-rupture value at 1800 F of 5000 psi, and for K151A a value of 12,000 psi.

Haynes Stellite Co. has recently published data on Metamic materials which are based on chromium and aluminum oxide. They show tensile strengths at 2000 F of over 11,000 psi and resist oxidation in air up to temperatures of 2192 F.

A number of other Cermet type materials have been developed and reported. These are based on the borides and silicides of the refractory metal elements such as zirconium, titanium, molybdenum and tungsten. Data on most of these are restricted, but it can be said that their strengths are high and the temperature of use has been increased well over that of the metal base materials. Disadvantages of these materials are that alloying increases the density of the materials, and that the design of some components must be changed to accommodate them. Thermal shock resistance is improved, but the degree is not as great as would be expected. Also inspection techniques must be improved or totally revised if materials of this type are to be more generally used.

Design utilizing heat-resistant materials must be based on: (1) Strength at elevated temperatures, either yield strength for short-time operation or rupture and creep for long-time operation; (2) strength-to-weight ratio; (3) oxidation resistance; (4) thermal stresses (thermal shock resistance); (5) modulus of elasticity; (6) relaxation properties and (7) fatigue life. It is evident that selection of a material for high-temperature service often involves a compromise of the required attributes. From available information, a logical selection of the best material appears possible in most cases, but the success of a particular material can only be verified by actual use.

PROTECTING IDEAS

By Albert Woodruff Gray
Jackson Heights, L. I., N. Y.

AN ANIMAL or bird captured in the woods and shut up in a cage is the property of its captor so long as he keeps it in the cage. When he lets it escape it no longer belongs to him. His right to possession continues only so long as his possession continues.

An idea and the exclusive right to its use is identical with a wild animal in captivity. The idea is property so long as it is confined by secrecy or by contract.

Delay: A Pennsylvania manufacturer many years ago was making rotary prospecting drills under regularly issued patents. Ten years before these patents were issued a stranger had conceived of a rotary drill of the same type, had made rough sketches of his plans but had made no model and done nothing beyond making these preliminary rough drawings.

". . . mere conception which is not followed by some practical steps counts for nothing . . ."

Five years after these patents had been issued the drill designer whose activity had carried no further than the drawing board applied for, and was granted, a patent. He then sued the manufacturer, claiming an infringement on his patent.

"Mere conception," said the federal court, "which is not followed by some practical steps counts for nothing against a subsequent independent inventor who, having complied with the patent laws, has obtained his patent. It would be indeed a strange perversion of the patent laws if one who had conceived of a new device and proceeded so far as to embody it in rough sketches or even in finished drawings, could there stop and yet hold that field of invention against all comers for a period of fifteen years.

"The law does not so regard supineness. Illustrative drawings of conceived ideas do not constitute an invention and unless they are followed by a reasonable observance of the requirements of the patent laws they can have no effect upon a subsequently granted patent to another."

This was supplemented by the court with a significant comment in relation to the protection of those ideas that are beyond the pale of the patent laws.

"For what it may be worth to its originator, the idea of the second patentee is granted protection albeit that it fails to come within the purview of the patent laws, either by reason of delay, or being a too abstract concept or any one of the many grounds on which a patent may be refused."

Disclosure: A letter was written a few years ago to one of the large automobile manufacturers. "A very serious error has been made in the general location of several of the individual units of your car. Within another year or so this error will reduce sales by possibly a million or several million dollars. The cost of overcoming this defect should not be over twenty to thirty cents, if you take the easiest and shortest way. I would like to have you make me an offer stating how much you would offer and pay for the same."

This idea, submitted at the suggestion of the company, was to relocate individual units and thus balance the weight of the steering unit as well as the weight of the driver.

"The battery should be moved from the left side to the right side. This would take about fifty pounds from the heavy side and add it to the light side. Then

". . . if in fact the manufacturer did derive benefit. . . they are not indebted to its author because they did not offer to make any agreement to pay for such mere suggestion . . ."

either or both the starter or generator should be moved to the right side of the motor."

The company declined to accept the suggestion, saying that it was not advisable to redesign the springs of the car at that time. Later the author of this plan sued the company for the value of the suggestion, claiming it had been subsequently adopted by the manufacturer.

"If in fact the manufacturer did derive benefit from the idea that the units of the car should be shifted and if their subsequent redisposal of some of the units to the other side of the car body was in any wise inspired by this idea," said the court, "they are not indebted to its author because they did not offer to make any agreement to pay for such mere suggestion.

". . . the abstract must have been resolved into the concrete. The patent must be for a thing—not for an idea merely . . ."

"When he voluntarily divulged his mere idea and suggestion, whatever interest he had in it became common property and as such was available to the manufacturer."

Thus, like the little animals in the woods, the idea had escaped and had become the property of no one possessor but of all.

Abstract Ideas: The restriction of patent laws to mechanical devices and processes of art, leaves outside their protection ideas that have not been nor cannot from their nature be embodied in concrete shape. A famous comment was made in a federal court decision in relation to an idea for drawing waste combustible gases from blast furnaces for use in reverberatory or other furnaces.

"There is no doubt that he who has discovered some new element or property of matter may secure to himself the ownership of his discovery so soon as he has been able to illustrate it practically and to demonstrate its value. The abstract must have been resolved into the concrete. The patent must be for a thing—not for an idea merely. This limitation, it may be said, denies to some of the more important products of mind what it concedes to others of a lower grade. But it is not the less true on that account. Men may be enriched or made happy by physical as well as by moral or political truths, which nevertheless go without reward to their authors.

"He who devised the art of multiplication could not restrain others from using it after him without payin for the license. The miner who first found out that the deeper veins were the richer in metal could not compel his neighbor to continue digging near the surface.

"The more comprehensive truths of all philosophy, whatever specific names we give to them, cannot be separately appropriated by any one. It is their practical use that brings them within the domain of individuals and it is the novelty of such an application that constitutes the proper subject of the patent."

Breach of Confidence: The defense to a recent action in Connecticut against an airplane manufacturer for the infringement of an automatic lubricating patent for air-cooled radial engines, was that the patent was invalid. In the negotiations between the parties the inventor had disclosed the details of this invention to an official of the company where, he contended, his idea was used in violation of his confidence and the agreement.

"I asked him whether it would be all right," related the patentee of the disclosure prior to the issuance of the patent, "that I was taking him into my confidence because I did not have any patents on that part of it; that I was disclosing something that was not covered by any patents. He assured me that anything I should mention or talk to him about automatic lubrication would be held in perfect confidence and that he would not permit it to become public in any way. A company of their reputation, he said, would not consider doing anything that was not right to any inventor."

Of this phase of the transaction, the traffic in ideas —irrespective of the patent—the federal court said, "The question has several times arisen whether if he has imparted the disclosure to another under an implied promise not to use it—in confidence—he may hold the promisor after the patent issues. Clearly he should be allowed to hold him for any breach during the period between the imparting of the secret and the issuance of the patent. He may also hold him on the notion that whether the patent be valid or not the promisor has surrendered his privilege as a member of the public.

". . . the inventor was relying . . . solely on the common law that prohibits a wrong-doer from the disclosure of information . . . obtained under circumstances that bound him to secrecy . . ."

"No doubt the parties may agree, if they wish, that the promisor shall not use the pending patent, should the pending patent issue but turn out to be invalid. Indeed they might even agree that he shall not use it even if the patent proves valid—the patentee might wish more than seventeen years protection. But the expression of such an intent should be explicit."

Common Law Rights: In another instance of this character, a mechanic was employed in making the mechanical parts of an invention with the agreement that any information relating to the work should not be disclosed. Thereupon this workman not only appropriated the information and invention to his own use but applied for and was granted a patent in his own name.

In the action that was the consequence of this betrayal of confidence the federal court pointed out that the inventor was relying, not on any patent nor any rights under that patent or the statute, but solely on the common law that prohibits a wrongdoer from profiting from the disclosure of information which he had obtained under circumstances that bound him to secrecy. Also that the wrongdoer was subject to an accounting of such profits as he had made by the wrongful use of the information, and the inventor entitled to an injunction against the further use or disclosure of this information.

Piracy of Ideas: Of the protection of ideas from the piracy of the unscrupulous the Supreme Court of Missouri recently said, in a case of this character, "Ideas have been compared to wild animals, property rights in which are dependent on possession and are lost by the escape of the wild animals and likewise by the disclosure of the idea. Of course there can be no property right in a mere abstract idea, but there may be in a particular combination of ideas or in the form in which ideas are embodied. Surely when ideas are embodied in a concrete plan for accomplishing a definite result the one who has conceived the plan has the right to contract with reference to its disclosure and to give instructions in its use even though he did not originate it in the sense that no one else ever had similar ideas."

A decision many years ago in an action in the New York courts has been repeatedly adopted as the law governing the protection of ideas from those who would reap where they have not sown.

". . . when ideas are embodied in a concrete plan for accomplishing a definite result the one who has conceived the plan has the right to contract with reference to its disclosure . . ."

A plan was submitted to a corporation in that state which later adopted and used the idea. The author of this plan sued for the value of his idea which he had given the company.

In holding he could recover nothing for what he had voluntarily surrendered, the court said:

"It is difficult to conceive how a claim to a mere idea, unconnected with particular physical devices for carrying out that idea, can be made the subject matter of property. So long as the originator or possessor of the naked idea retains it, it is property but it ceases to be his own when he permits it to pass from him.

"Ideas of this sort in their relation to property may be likened to the interest a person may have in beasts and birds and fish in running streams. If the claimant keeps them on his own premises they become his unqualified property and absolutely his own so long as they do not escape, but if he permits them to go he cannot follow them."

On appeal these restrictions thus outlined in the use of ideas were supplemented with a statement by the Court of Appeals in that state that outlines a method for the sound and substantial protection of ideas from appropriation by others.

"Without denying that there may be property in an idea or trade secret or system, it is obvious that its originator or proprietor must himself protect it from escape or disclosure. If it cannot be sold or negotiated or sued without disclosure it would seem proper that some contract should guard or regulate the disclosure, otherwise it must follow the law of ideas and become the acquisition of whoever receives it."

". . . so long as the originator or possessor of the naked idea retains it, it is his property but it ceases to be his own when he permits it to pass from him . . ."

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4. Picard v. United Aircraft Corp., 128 Fed. 2d 632, 43 F.S. 679
5. Becher v. Coutoure Laboratories, 29 Fed. 2d 31
6. Shonwald v. F. Burkhart Mfg. Co., 202 S.W. 2d 7, Missouri
7. Bristol v. Equitable Life Assurance Society, 30 N.E. 505, 5 N.Y.S. 131, New York

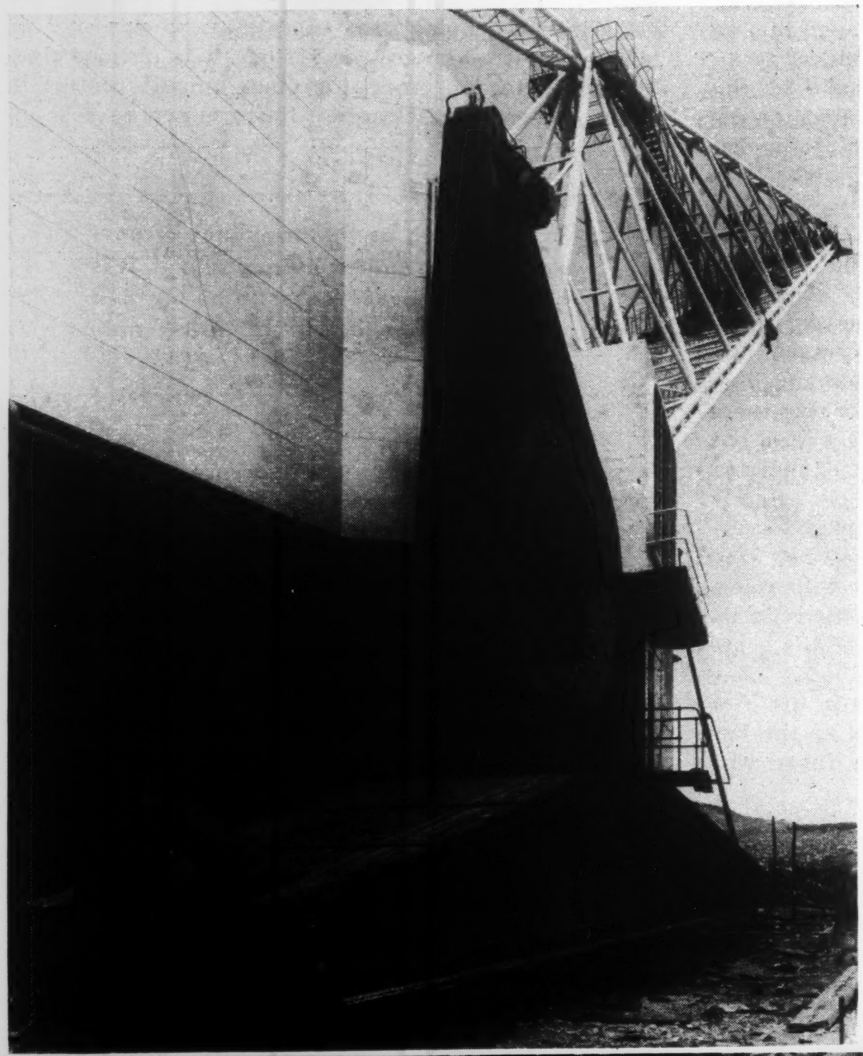
Correction

It has been called to our attention by the Fawick Airflex Co. Inc. that the range of their pneumatically operated clutch elements is considerably broader than was indicated in TABLE 1 of A. F. Gagne's "Clutch" article in the August issue of MACHINE DESIGN. They point out that the tabular information listed for external pneumatic gland designs represents only the catalogued extremes for their 16 through 45-inch clutch assemblies complete with spiders, drums, hubs, etc.

According to Fawick engineers, the following data represent the operating characteristics and dimensional capacity ranges of their complete line of regularly produced pneumatic-gland clutch elements: Engagement frequency, 360 to 4800 max per hour; engagement time, 0.2 to 2.0 seconds; nominal shaft diameter, $\frac{3}{4}$ in. to 12 inches; extreme diameter, 7 to $96\frac{1}{2}$ inches; capacity rating, $1\frac{1}{2}$ to 3600 hp; maximum speed, 2500 rpm (smallest) to 500 rpm (largest).

"An empirical fact has a short-lived usefulness; fundamental data and sound theory can be used over and over again without wearing out."—THOMAS K. SHERWOOD, *dean of engineering, Massachusetts Institute of Technology.*

CONTEMPORARY

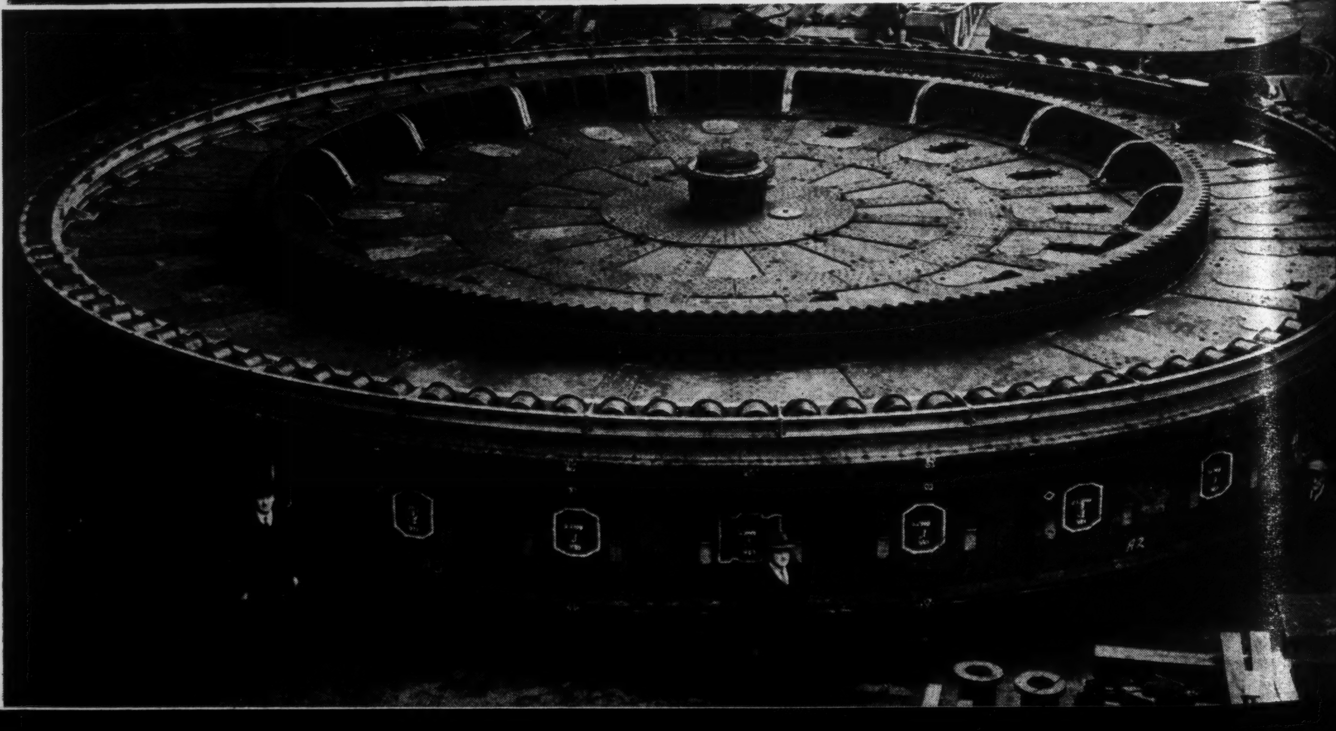


Mammoth Drag

GARGANTUA of open-pit mining machinery, the world's largest dragline unit, right, crawfishes about on location instead of travelling in customary fashion on endless treads. Despite its tremendous size, and total weight of nearly 1800 tons, this huge machine, known as the W-1400, can travel at the rate of 200 yards per hour in 7-foot steps on two cleated shoes, left, 9½ feet wide by 48 feet long.

When the dragline is in operation, total weight of the machine rests on a circular base structure 48 feet in diameter, below. On this base, the superstructure revolves on a segmented ring of 120 ten-inch tapered rollers. Rotary positioning of the cantilever jib is accomplished through a pinion drive to a circular rack over 33 feet in diameter. Teeth of this rack are 19 inches wide.

Designed around Cameron and Heath British patents, the walking gear is similar to that currently used on RapieR walking draglines.

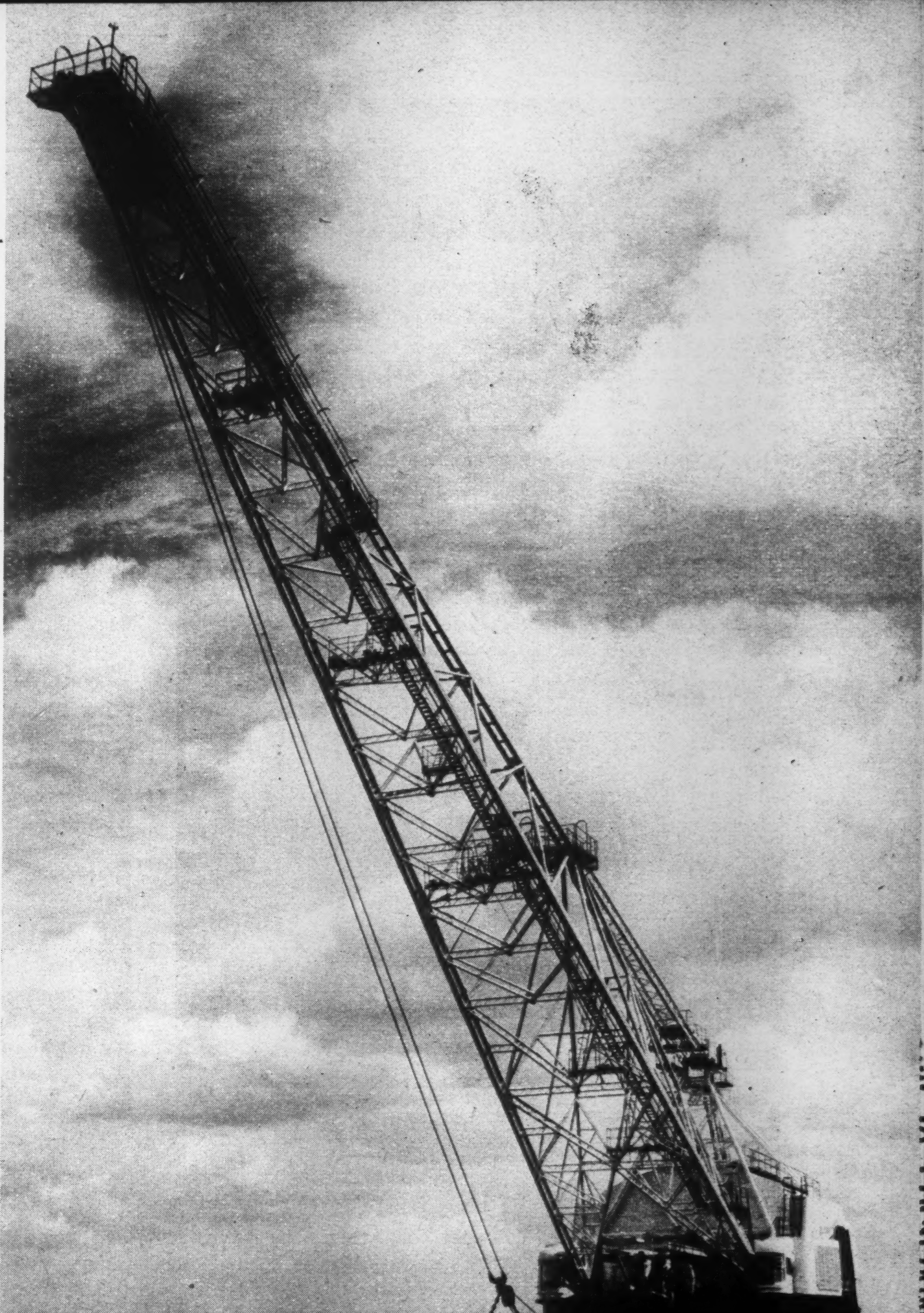


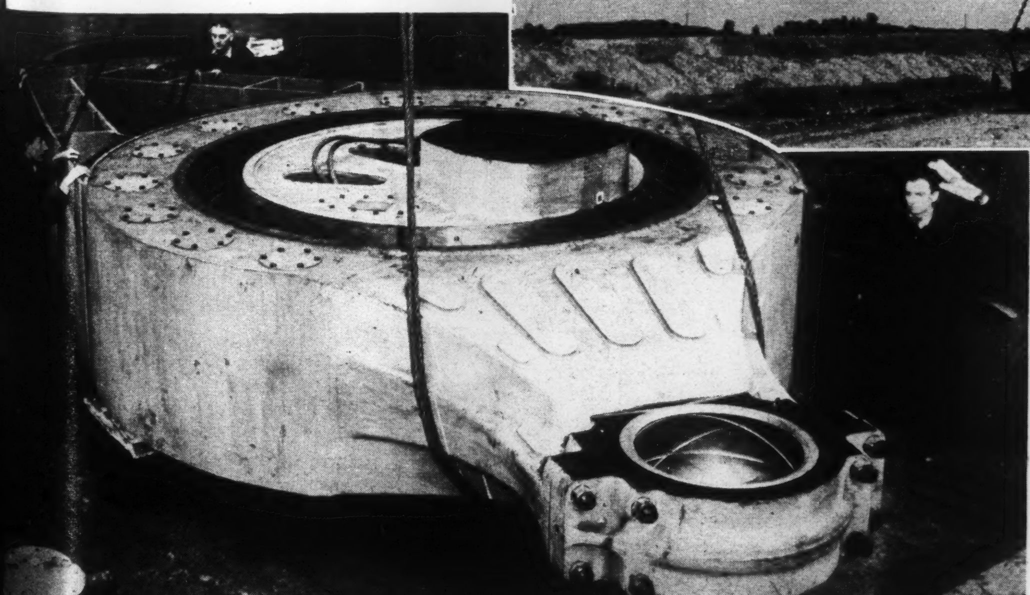
ESIGN

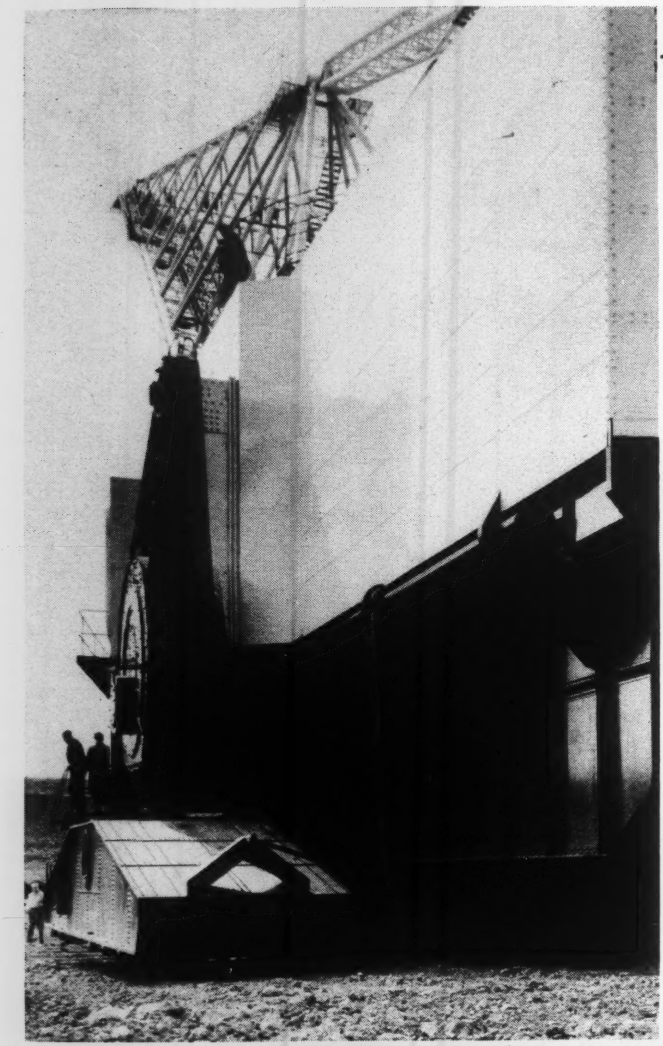
lks Backward

Each shoe is mounted by universal ball joint to a composite cast-fabricated "walking leg", photo below. The main or center bearings of the legs are driven through square-bored roller bearing eccentrics. These eccentrics are carried on separate driveshafts at the inner ends of which are mounted twelve-foot drive gears. Because of the unusually heavy drive load, each of these eleven-ton gears is driven by two diametrically opposed pinions to avoid bending moments in the driveshafts.

Walking reaction forces are transmitted to the main framework through articulating links at the top of each leg. During each "step", front end of the circular base actually remains on the ground, being dragged along as the eccentrics rotate. On completion of a step cycle, a torque tube equalizing arrangement, top left next page, levels the shoes to normal straight position about two feet







above the base in readiness for the next step.

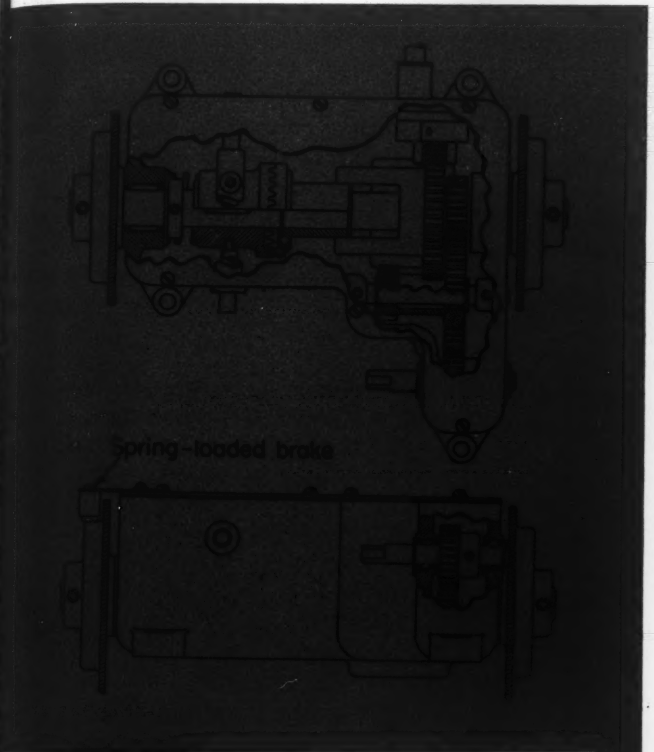
Alternating current at 6600 volts supplied through two trailing cables powers two motor-generator sets located in the hoist room. These generators provide direct current for a total of fourteen interchangeable drive motors aggregating 3150 horsepower. Duplicate "armchair" controls, below, are provided in air-conditioned cabs on both sides of the machine giving the single operator a choice of two stations. A gallery below and between the cabins houses recording instruments and affords a vantage point for time study operations under all weather conditions.

Extending 282 feet from the superstructure, the triangular jib of the dragline is of all-welded construction, utilizing high tensile chromium-molybdenum steel tubes, plates and forgings. Approximately 2¼ tons of Lincoln E-7010 welding electrodes, weighing about four ounces each, were used in fabricating the jib alone. With all equipment, catwalks etc., the Great Jib, as it has been "dubbed", exceeds 140 tons in weight and reaches 175 feet above ground level.

Weighing 25-tons, the drag bucket has an ore capacity of 30 tons. It is hauled by a pair of 2½-inch cables and hoisted by another pair of 2-inch cables. The bucket operates at a speed enabling the machine to mine its own weight in iron ore every hour. Designed by Ransomes and Rapier Ltd. for service at Stewarts and Lloyds' Prior Hall quarry, numerous British concerns built the various structures and machinery and participated in ultimate assembly of the machine at the ore pit.

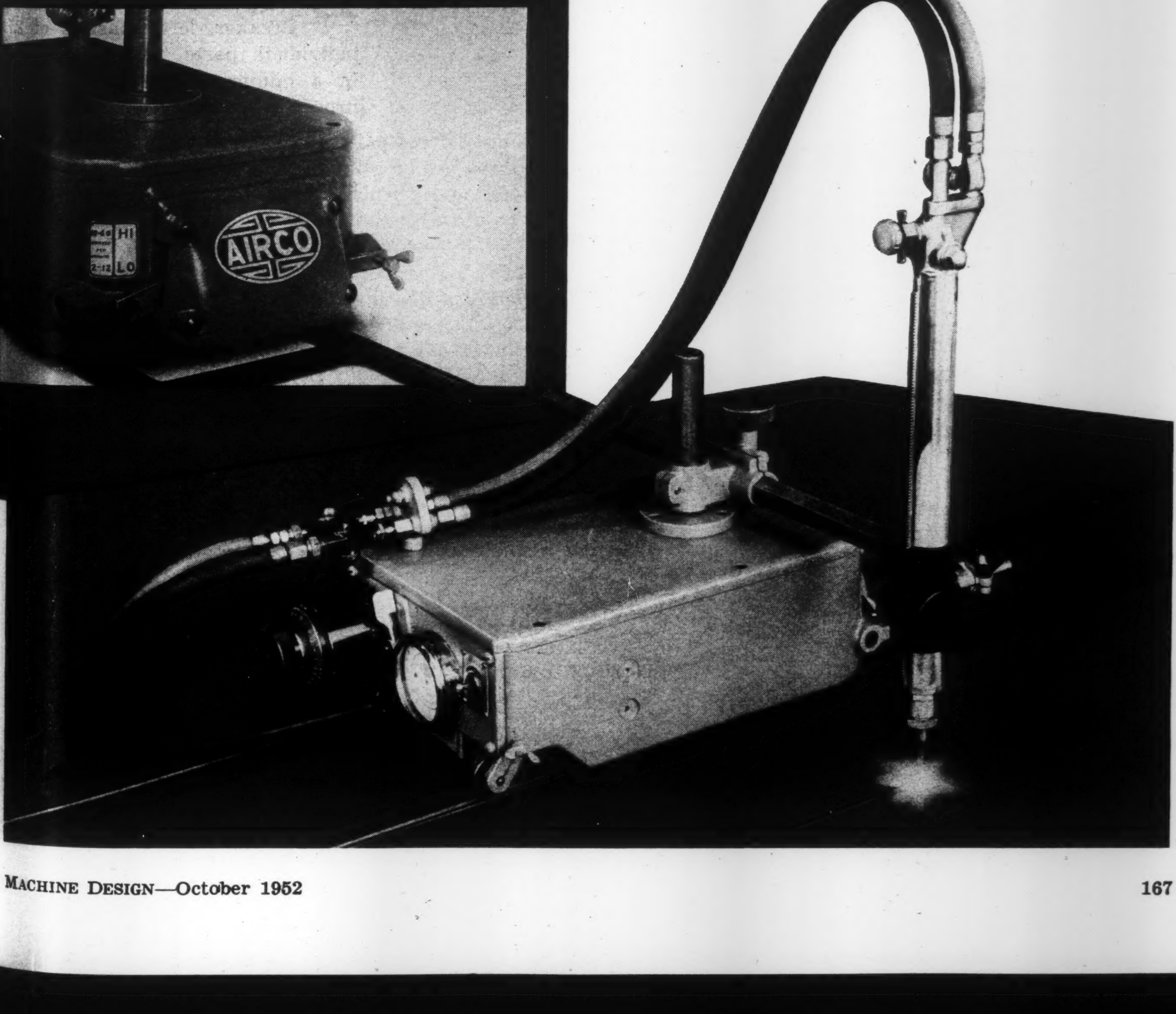
CONTEMPORARY DESIGN

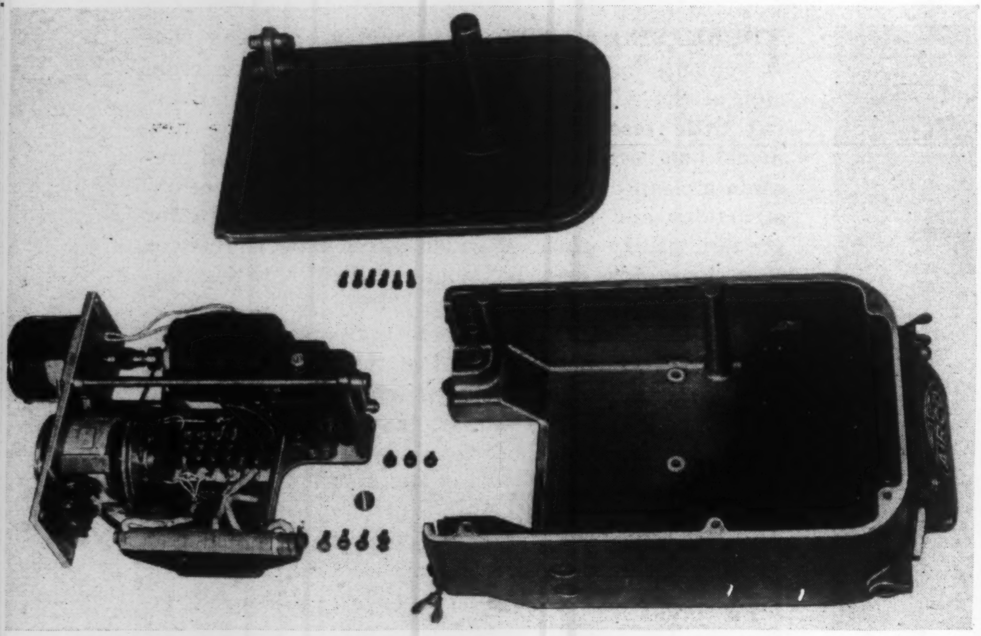
Redesign Cleanlines Torch Carriage



INCREASED flexibility and greater operating convenience have been realized through major redesign of the AIRCO No. 20 Radiagraph, below. Bearing little resemblance to its predecessor, the new model has been greatly simplified and in addition presents a clean outward appearance. Elimination of obstructions and projections outside the housing offer greater utility since a wider variety of equipment than heretofore can be mounted readily with minimum interference.

With one exception, all operating controls are conveniently grouped at one end of the machine. These controls are; a toggle switch having off, forward and reverse positions; a magnetic tachometer which indicates traverse speed in either direction in inches per minute; a clutch lever for disengaging the power drive; and a calibrated speed-control governor coupled directly to a variable-speed drive motor. Supplementing the governed speed control a control lever at the opposite end of the housing, left below, provides overlapping speed ranges of 2 to 12 and 10 to 60 feet per



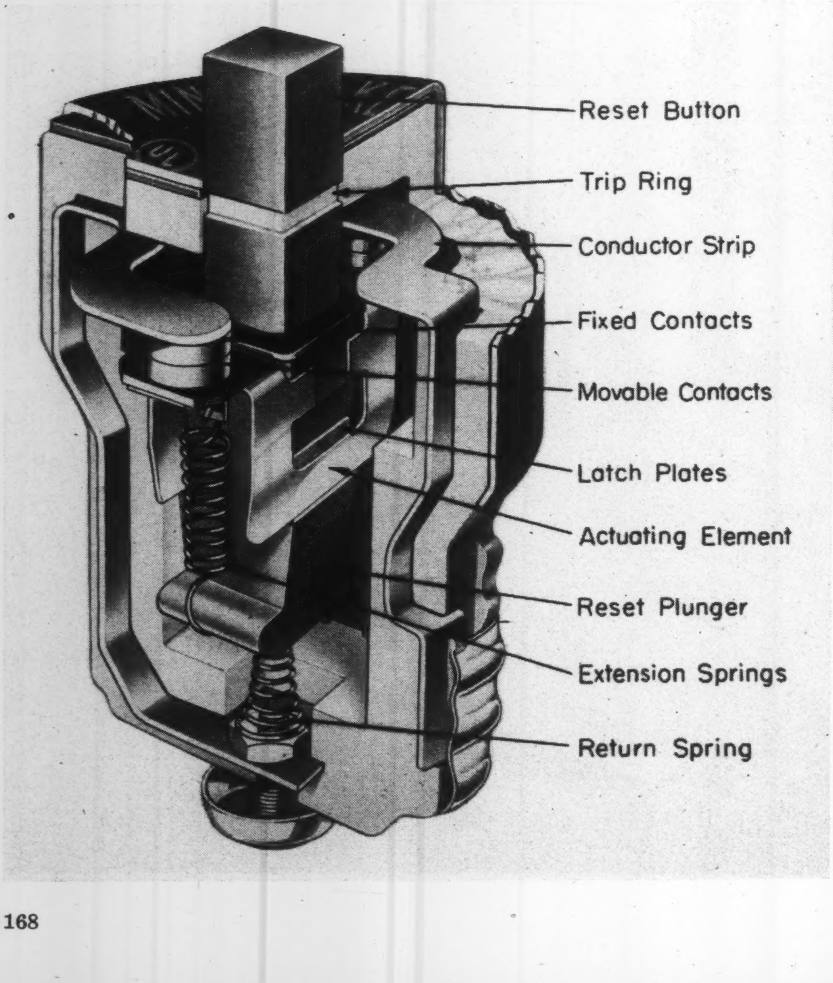


minute. This lever shifts a sliding gear in a spur gear drive transmission, top left, previous page, which is direct-coupled to the 220-440 v ac-dc gearmotor.

Traction is obtained through one only of two flame-hardened wheels of the drive assembly. Gear backlash is counteracted by a spring-loaded brake in constant engagement with the traction wheel rim. Also flame-hardened, the other two wheels are castered for contouring and circular travel. Through thumbscrews the casters may be locked to prevent swiveling.

Housing parts of the carriage, left, are heat and shock-resistant aluminum alloy castings with machined joints to seal out dust and dirt. The motor drive and control panel are mounted on a separate chassis, readily removable as a unit for convenient servicing and maintenance.

Miniature Circuit Breaker



EXEMPLIFYING design in miniature, the new Mini-Breaker, left, consists of 25 individual parts neatly arranged in a minimum of space. Shockproof in construction, this comparatively tiny electrothermal circuit breaker is designed to fit standard Edison-type fuseholders.

Under normal conditions, including temporary line surges and starting loads, current is conducted through a pair of spring-held contacts mounted on a U-shaped bimetallic stamping. When heated because of a "short" or a sustained overload, the bimetal element spreads and disengages from a pair of latch plates on the reset plunger. This permits twin extension springs to pull the movable contact assembly away from the stationary contacts.

Simultaneously with contact release, a compression spring pushes the reset button outward to expose a normally hidden telltale groove in the plunger. The groove indicates, by sight and touch, that the circuit has been interrupted. Under ordinary circumstances, this breaker, made by Mechanical Products Inc., will carry full load upon reset after ten-seconds cooling.

Gear Blanks

. . . the key to good gear design

By Louis D. Martin
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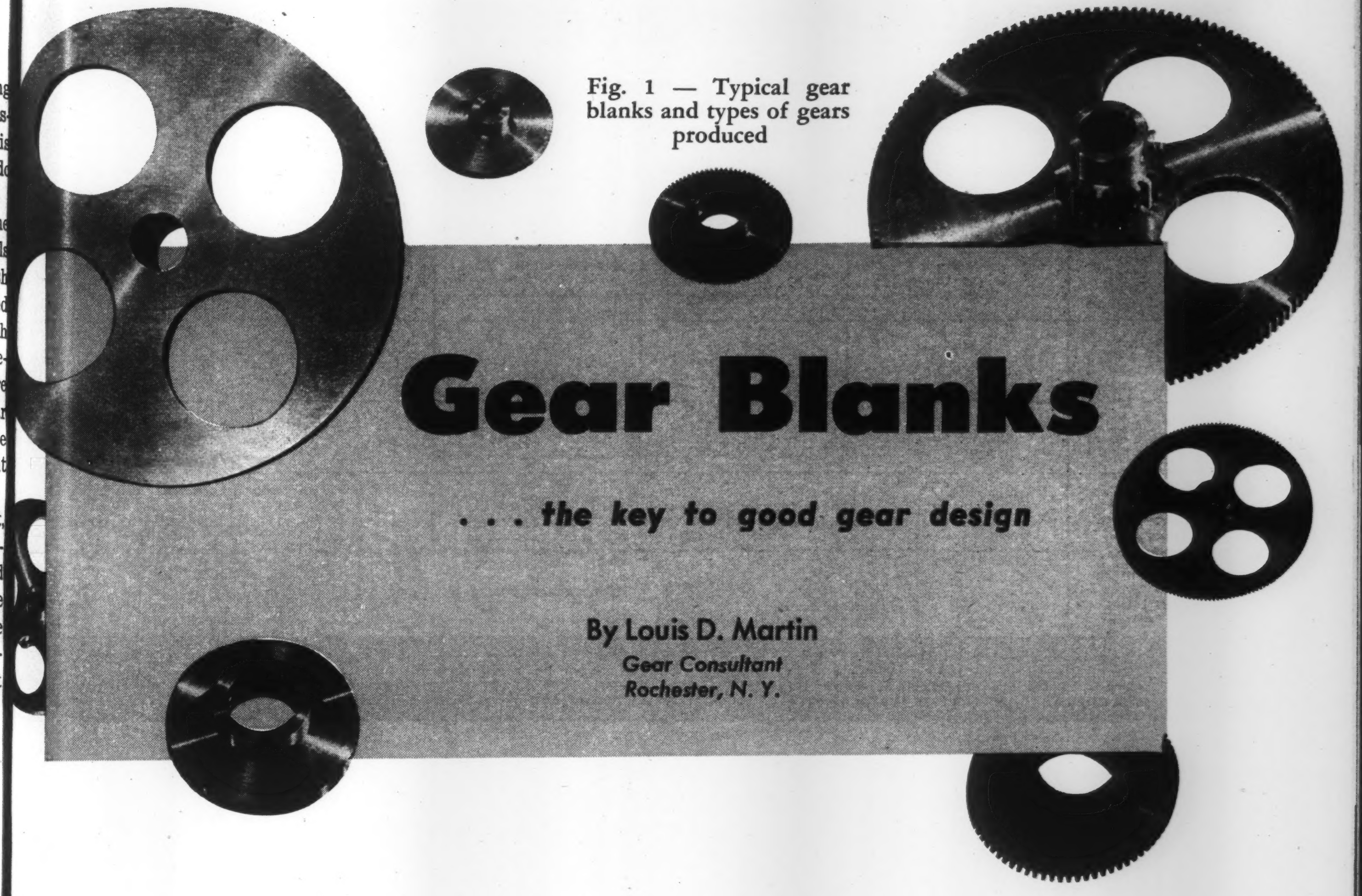
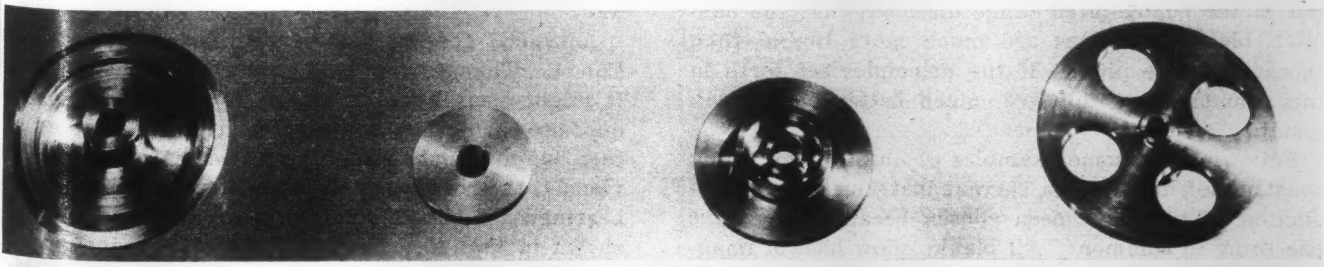


Fig. 1 — Typical gear blanks and types of gears produced

GOOD gears start with good blanks. Design and quality of a gear blank determine the accuracy and performance of the finished gear. This is true of all blanks, large or small, whether for power drives or for precision instruments, *Fig.* 1.

In instrument gearing, in particular, lack of realism and understanding of manufacturing difficulties on the part of designers is evident. Many gears have been designed without consideration of the problems posed in their manufacture. Often very close tolerances are specified for the finished gear that cannot be satisfied because of blank design. In some cases, designers do not consider alternative methods of constructing a gear blank. If ample consideration is given to blank design and if those who will have the task of manufacturing are consulted, a better and cheaper blank construction will usually result.

Primarily, gear blanks should be designed to avoid excessive localized stresses and deflections within themselves. Blank rigidity is also necessary for proper chucking when cutting the teeth. This point is important because it affects the overall quality of the gear and the efficiency of the cutting operation. For this reason bores, hubs and other locating surfaces must be in proper proportion to the diameter and pitch of the gear. Wherever possible, small bores, thin webs, or any condition which necessitates excessive overhang in cutting should be avoided. It is desirable to provide the gear blank with locating surfaces of generous size machined square with the bore.



[illegible]

Class	Commercial			Precision	
	1	2	3 & 4	1	2 & 3
Diameter of Bore	0.002	0.001	0.0007	0.0005	0.0002
Taper of Bore*	0.001 per in. of length Max 0.002	0.0007 per in. of length Max 0.001	0.0005 per in. of length Max 0.0007	0.0003 per in. of length Max 0.0005	0.0002 per in. of length Max 0.0002
Lateral Runout of Spur and Helical Gears	0.002 per in. of radius Max 0.004	0.0015 per in. of radius Max 0.0025	0.001 per in. of radius Max 0.002	0.0007 per in. of radius Max 0.0015	0.0005 per in. of radius Max 0.001
Lateral Runout of Bevel and Face Gears	0.001 per in. of radius Max 0.002	0.0008 per in. of radius Max 0.0016	0.0005 per in. of radius Max 0.001	0.0004 per in. of radius Max 0.0008	0.0003 per in. of radius Max 0.0005
Nonparallelism	0.002 per in. of radius Max 0.004	0.0015 per in. of radius Max 0.0025	0.001 per in. of radius Max 0.002	0.0007 per in. of radius Max 0.0015	0.0005 per in. of radius Max 0.001
Concavity of Mounting and Registering Surfaces	0.001 per in. of radius for rigid blanks. 0.0005 per in. of radius for flexible blanks. Total not to exceed 0.003			0.0005 per in. of radius for rigid blanks. 0.0003 per in. of radius for flexible blanks. Total not to exceed 0.0015	
Convexity of Mounting and Registering Surfaces	None for any class				

[illegible]

Note: The outside diameter tolerance of spur and helical gears should be obtained from American Standard 20-Deg Involute Fine-Pitch System for Spur and Helical Gears (ASA B6.7-1950). The tolerance for face angle, back angle, crown to back tolerance and outside diameter of bevel gears should be obtained from American Standard Fine-Pitch Straight Bevel Gears (ASA B6.8-1950).

In bevel gears, these locating surfaces should be suitable both for locating the blank in the gear cutting machine as well as for locating the finished gear when assembled. The most common faults which have proved troublesome in gear blank design are:

1. Very small bores compared to outside diameters
2. Very large bores compared to outside diameters
3. Narrow face width with large outside diameter
4. Short bore length
5. Thin hub walls
6. Keyways breaking through hub walls
7. Gears integral with shafts that lack stiffness.

In Section Seven of *American Standard Inspection of Fine-Pitch Gears* (ASA B6.11-1951) tolerances for various gear-blank elements are set up to produce finished gears of given degrees of accuracy. This standard gives valuable guides on gear-blank construction. An excerpt from this standard, *Fig.* 2, shows blank nomenclature as well as a few examples of good and bad construction. In TABLE 1 are shown blank tolerances for the various classes of gears covered in this standard. The tolerances given in this standard are realistic and liberal. A comparison of the tolerances for the various elements of fine-pitch gear blanks with those of blanks that would normally fall in the coarse-pitch range discloses that the fine-pitch blank tolerances are much more liberal than those of coarse pitch. If the principles set forth in this standard are followed, much better blanks will result.

Following are some examples of questionable blank construction taken from current instrument gear production. They have been chosen because they have one thing in common: All blanks show lack of imagination and knowledge of good machining practice. Space does not permit a broader choice although it would not be difficult to find other examples.

An example of a gear blank with a hub too small for its diameter is illustrated in *Fig.* 3. In addition to this, the keyway breaks through the thin hub as shown in *Fig.* 3*a*. In this case, the bore tolerance was 0.0003-inch, difficult enough to produce when in an unbroken hole. The designer added to the difficulty by not foreseeing that the keyway would break through its hub.

Three holes are provided in this blank which make a difficult finish facing operation due to the impact cut introduced by the holes. To add to the problems, a material that had poor machinability was chosen. A blank of this kind should have the area on each side of the holes relieved, as shown in *Fig.* 3*b*. The relief can be put in the roughing operation before the large holes are cut. The final facing operation, necessary to produce the required trueness of the mounting faces, can then be performed much easier. Instead of facing the entire distance, from edge of hub to outside diameter, locating from a small hole, only the center and rim are faced true with bore. This is simpler and leads to greater accuracy because it avoids the chatter introduced by the impact cut from the holes. Functionally, the gear will work just as well.

A typical gear with a shouldered bore is shown in *Fig.* 4. The gear is well proportioned in this case. It might seem an easy matter to produce two bores opposite each other, and each square with the locating face but to the shop man it poses a real problem. Obviously, the reason for the shoulder is to position two bearings. A simple solution is to use a snap ring as shown in *Fig.* 4*b*. There are several standard makes available. The trick in cutting the groove for the ring is to put a slight angle of approximately one de-

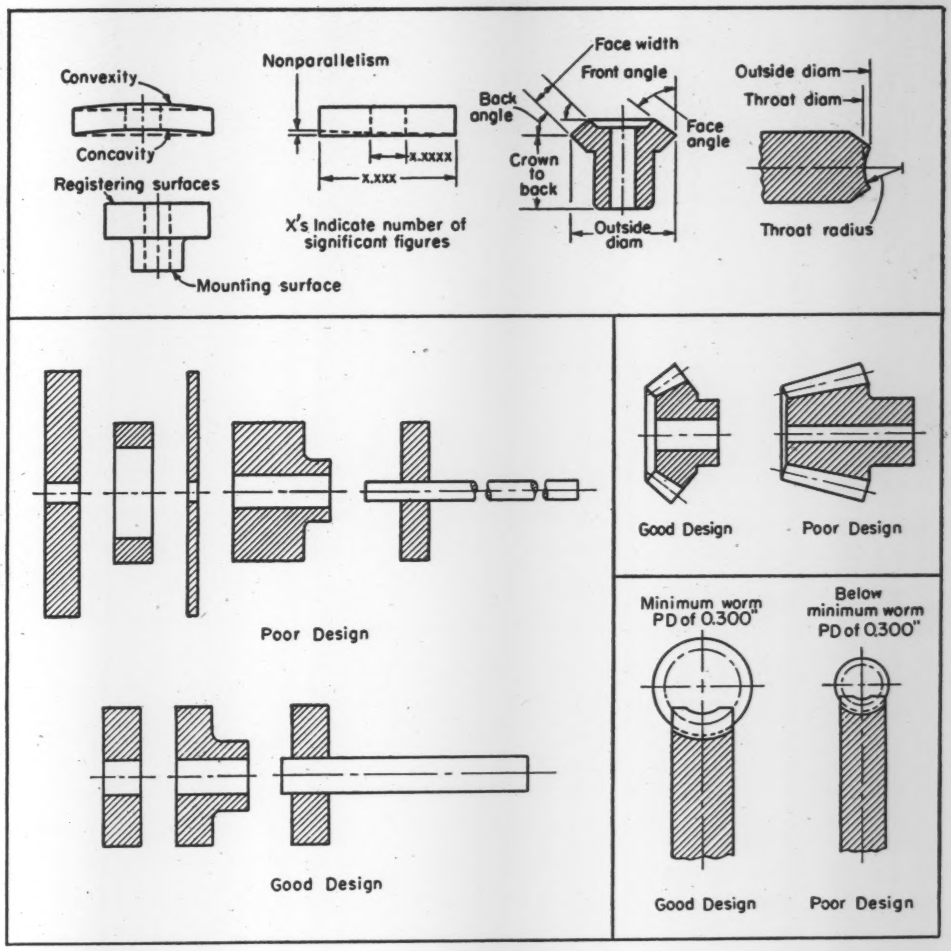
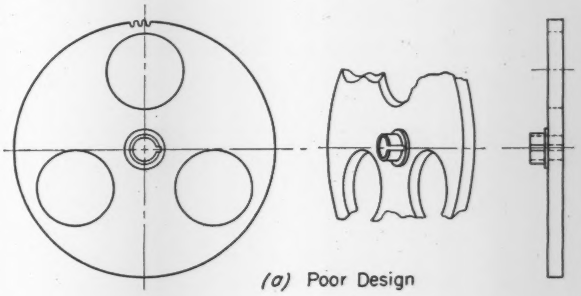

Convexity
Concavity
Registering surfaces
Mounting surface
Nonparallelism
x.xxxx
x.xxx
X's Indicate number of significant figures
Face width
Front angle
Back angle
Crown to back
Face angle
Outside diam
Outside diam
Throat diam
Throat radius
Poor Design
Good Design
Good Design
Poor Design
Minimum worm PD of 0.300"
Below minimum worm PD of 0.300"
Good Design
Poor Design

Fig. 2 — Gear blank nomenclature and examples of good and bad construction

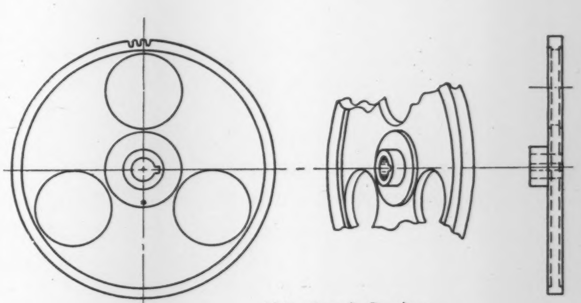
gree on each side of the groove as shown in the enlarged view. The width at the small end of the tapering groove is a few thousandths smaller than the minimum washer thickness. The ring is never permitted to reach the bottom of the groove, but is held tightly on its angular faces. By this simple expedient, a hub is produced which is just as good as the solid design. A construction like this will permit boring straight, accurate holes and will improve bearing alignment. Costs will be reduced and yield increased.

A common error in bevel gear blank design and one which seems difficult to overcome is shown in *Fig.* 5*a*. Some designers insist on making bevel gears with a front hub that extends beyond the cone point. Such a gear can only be produced by one method, namely, by generating with reciprocating tools. The gear can only have straight teeth and, to make matters worse, it cannot be produced on the latest fine-pitch bevel gear generators. It happens that straight-bevel generators, suitable for the smaller fine-pitch gears, are now obsolete. They have been superseded by a better machine which employs rotary cutters. Occasionally, a hub extension is desirable, and to design around it would perhaps be a major undertaking. In such a case, why not use a two piece construction?

Shown in *Fig. 5b* is a two-piece construction in which the gear has an accurately made bore. The teeth can be either straight or spiral, and can be cut on the latest equipment. The hub is a flanged bushing which is dimensioned as an interference fit in the



(a) Poor Design



(b) Good Design

Fig. 3—Gear blank with hub too small for the bore is shown at *a*. Frail hub is broken through by keyway. Redesigned blank at *b* has adequate hub

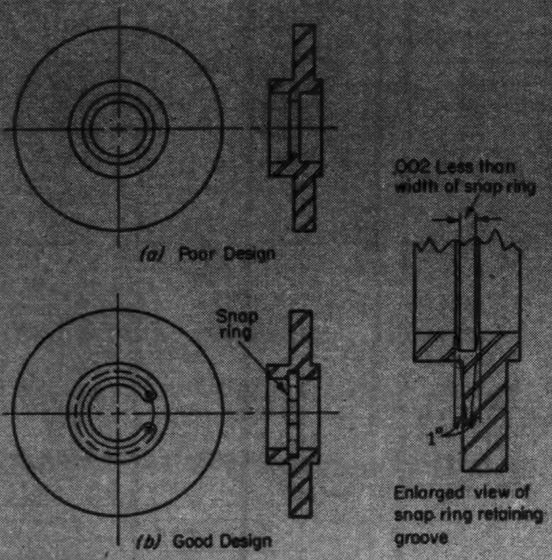

(a) Poor Design
.002 Less than width of snap ring
Snap ring
1°
Enlarged view of snap ring retaining groove
(b) Good Design

Fig. 4—Typical example of a blank with a shouldered bore. Bore at *a* is difficult to produce. Snap ring in groove at *b* is better

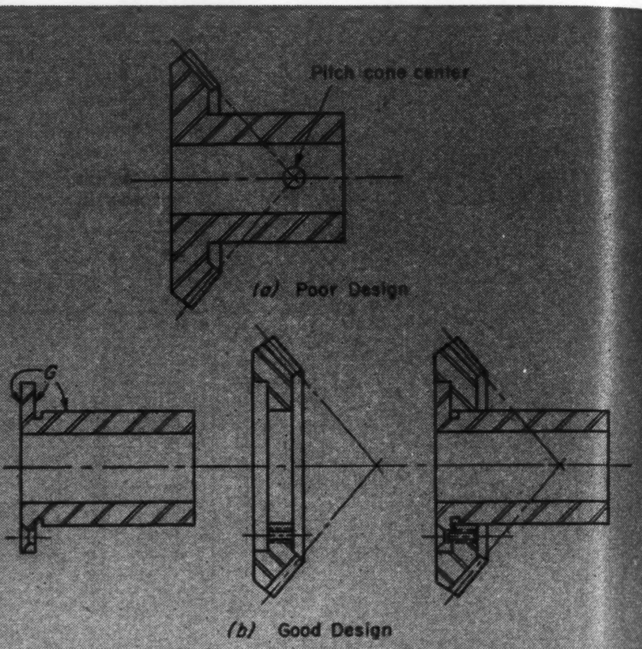


Fig. 5—Bevel gear with front hub extending beyond the pitch cone point. Solid piece design at *a* is poor. Two-piece design at *b* is far better

gear. The fitting of the bushing to the gear is done by one of two methods: heating the gear an amount suitable to expand its bore for a proper fit in its bushing or refrigerating the bushing to cause it to shrink a suitable amount. Also, a combination of the two may be employed by both heating the gear and shrinking the bushing, depending on the relative diameters.

It may be that over-conservatism may demand the use of screws or rivets to attach the hub to the gear in addition to the shrink fit. Such a construction is indicated in *Fig.* 5*b*. When the bushing is fitted into the gear, its bore will probably close up a trifle. Honing or lapping will correct this condition. Each case of this kind will require separate study. It is suggested that designers consult their shop men when they have a problem of this kind. A good mixture of practice and theory will inevitably lead to the best solution.

In *Fig.* 6, showing a cluster-gear blank of stainless steel, it will be seen that, in order to obtain the pinion for the cluster, all of the material in the shaded area is wasted. Actually, it takes considerably more material and labor to turn down the bar stock for the pinion than that consumed for the gear. This is another case where a two-piece construction is indicated. Referring to *Fig.* 7 which shows the two piece construction, the gear can be made from sheet or bar stock. The sides should be recessed as shown, similar to the gear in *Fig.* 3. In this stage, the blank can be bored to size to fit the pinion and rough turned. The four holes can be put in next. The pinion blank is finished to size with the exception that the bore has a small allowance for honing or lapping after it is shrunk into the gear blank.

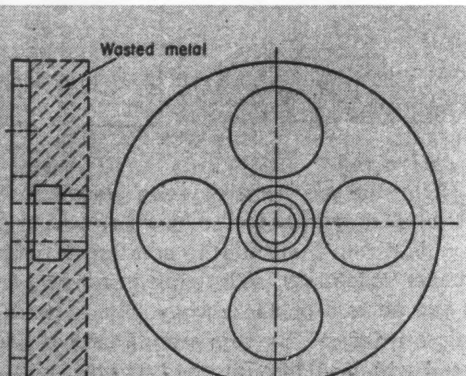
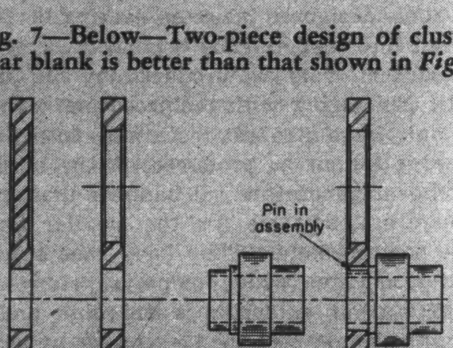


Fig. 6—Above—Cluster gear blank of stainless steel. Shaded area represents wasted metal

Fig. 7—Below—Two-piece design of cluster gear blank is better than that shown in *Fig.* 6



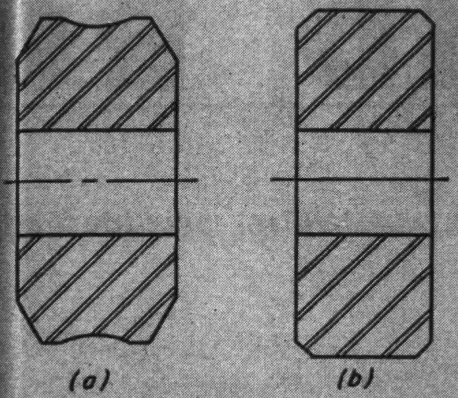


Fig. 8 — Worm-gear blank. Throated blank is shown at *a* and nonthroated blank at *b*

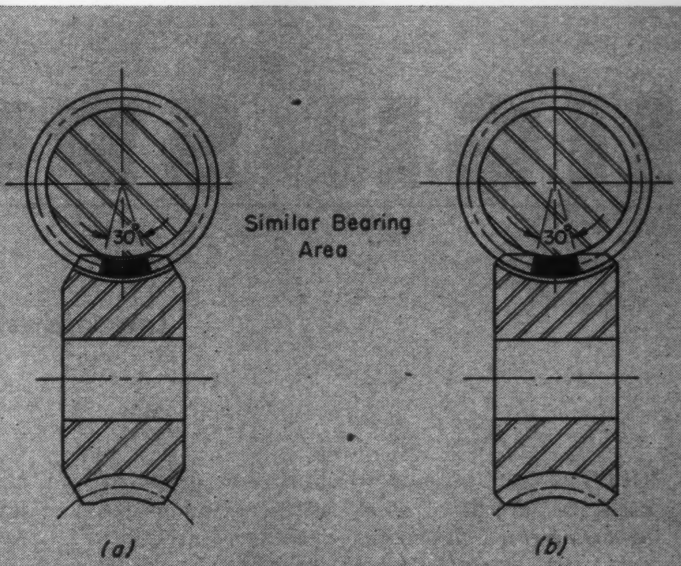


Fig. 9—Throated and nonthroated worm gears at *a* and *b* respectively. Both have the same contact area

In this case it may also be desirable to increase the factor of safety by pinning the pinion to the gear blank in assembly. The final facing operation of the rim and center of the gear is done from the finished pinion bore. This two-piece construction would not only save labor and material but also permit salvaging the gear and pinion if either were out of drawing tolerances. There is little doubt that this construction would be equally as satisfactory as the one-piece construction.

In the fine-pitch instrument field, throated worm gears are sometimes used. It is customary to make the worm-gear blank as shown in *Fig. 8a*. A simpler blank design is shown in *Fig. 8b*. In this construction, the blank is not throated and resembles a spur-gear blank. This type of blank is recommended for motion drives where loads are relatively light. *American Standard Design for Fine-Pitch Worm Gearing* (ASA B6.9-1950) gives two choices of worm-gear blank design. One like that shown in *Fig. 8a* and the other, without a throat, like the one shown in *Fig. 8b*. The nonthroated gear blank may seem to have less area of contact than the throated blank. This area of contact can be increased somewhat when a tapping hob is used. In such case the root of the hob produces the throat as shown in *Fig. 9b*.

The fallacy in using a fully throated blank, especially in instrument gears is that it is never possible to produce fine-pitch worm gears that fully envelop the worms. This is due to the limitations in the generating equipment available for this type of gear.

Fine-pitch worm gears are produced by the in-feed method of generating, in which the hob is larger than the mating worm by a suitable sharpening allowance which has been more or less standardized. The lead angle of the hob is different from that of the worm and continually changes as the hob diameter changes by sharpening. To compensate for this, it is common practice to adjust the hob axis slightly from the 90-degree relation with the axis of the work spindle. It is not generally appreciated that a change in the center distance between a worm and worm gear changes conjugate action. The amount of change depends on many factors such as : axial pitch, lead angle, depth of cut, and pressure angle.

The equipment for producing fine-pitch worm gears by the in-feed method does not have facilities for maintaining constant center distance like tangential-feed worm-gear hobbing machines used for coarse-pitch gears. Size is obtained by varying the center distance and endeavoring to correct for bias bearing by changing the hob axis. Fully conjugate contact is therefore impossible. Furthermore, it is useless to design a complicated blank in an endeavor to obtain maximum contact when the limitations of the process is the governing factor.

The committee that developed the fine-pitch inspection standard must have recognized these limitations because, in the section on inspection of fine-pitch worm gears, under Item 78, "Required Initial Area of Contact," is stated, "A minimum of 50 per cent contact is suitable for most fine-pitch worm gears."

Figure 9*a* shows a throated worm gear with approximately 50 per cent bearing contacting its mating worm. *Fig. 9b* is the same worm in mesh with a nonthroated worm gear. It is obvious that the simpler nonthroated worm-gear blank will work just as well.

This highlights a few basic considerations to show that good gear blanks are important. Without a good foundation it is not possible to build an enduring structure. By the same token, without good blanks, it is not possible to produce good gears. No amount of "do's and don'ts" will ever constitute a formidable substitute for that priceless ingredient—good common sense. More of it in blank design is in order.

HIGH-SPEED RO

Ingenious crank mechanism provides adjus

EVOLUTION of the modern cut-off for producing accurate lengths of stock from continuous web processing machines has been necessitated to keep pace with increases in production speeds, requirements for more accurate cuts and for changing the length of cut without stopping the flow of material. In the rotary cut-off for corrugated paper board, *Fig.* 1, accuracy of cut is maintained at any line speed up to 500 feet per minute. This has been made possible through the development of a double-crank mechanism to drive rotary shears at line speed during cut-off regardless of the cut-length setting.

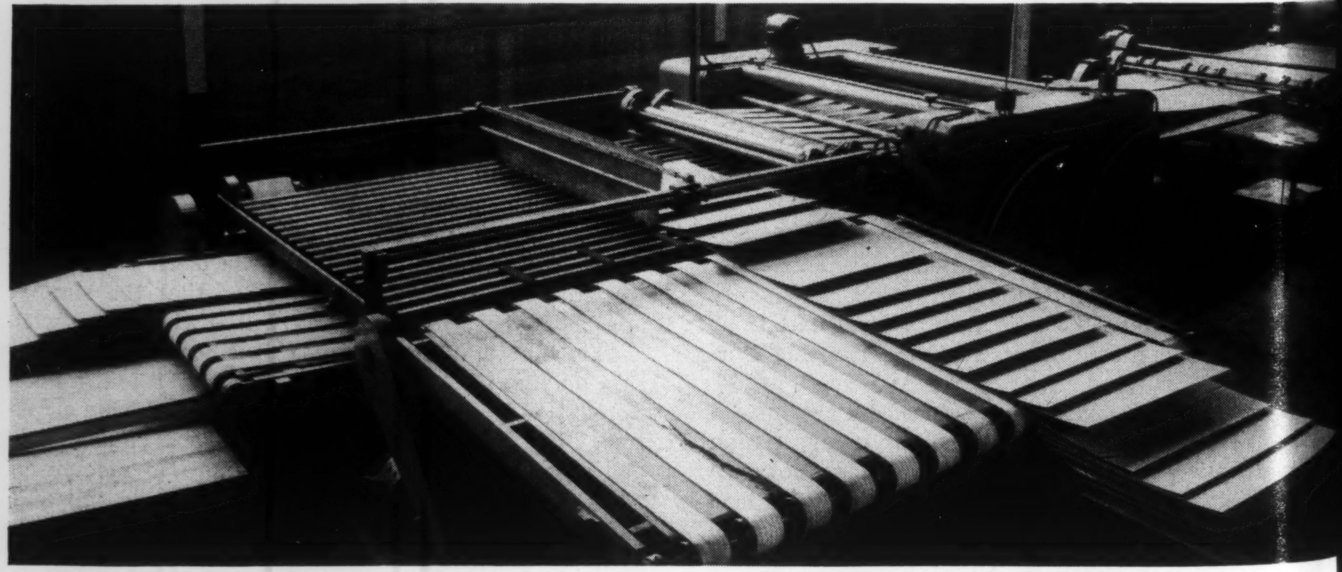
Cutting the web in accurate lengths has been one of the most troublesome and one of the most important problems faced by the designer as a result of ever increasing production speeds. Less than fifty years ago, corrugated board machines were running at 20 feet per minute and cut-off operations were relatively simple. With the advent of quicker setting adhesives and other improvements, better mechanical methods of cutting the web had to be devised.

Early cut-offs were of the flying shear type and were equipped with a target trip located in the path of the board which triggered a one-revolution clutch and brake. The drive was geared to synchronize the knife with the paper speed at the cutting point. Because the knife stopped between each cut, no other means of synchronization was necessary. When production speeds rose above 150 feet per minute, starting and stopping the mass of this type of shear became destructive. A continuous running type of guillotine cutter was then developed. It retained the arms and crank of the target trip knife but the frequency of cut and hence the length of blank were determined by an elaborate change gear box.

For synchronizing the speed of this knife with the paper, to minimize buckling or tearing, a change gear box and an elliptical-gear differential were employed to obtain proper speed at the point of cutting. For every setting of this gear box for sheet length, there was a corresponding adjustment of the elliptic differential to bring the knife to paper speed at the moment of cut. This machine was sufficiently accurate but, because of the complex gear box, it was relatively expensive. In addition, it required considerable down time for adjusting the gears, etc., for each change in sheet length.

It was soon realized that a mechanical variable-

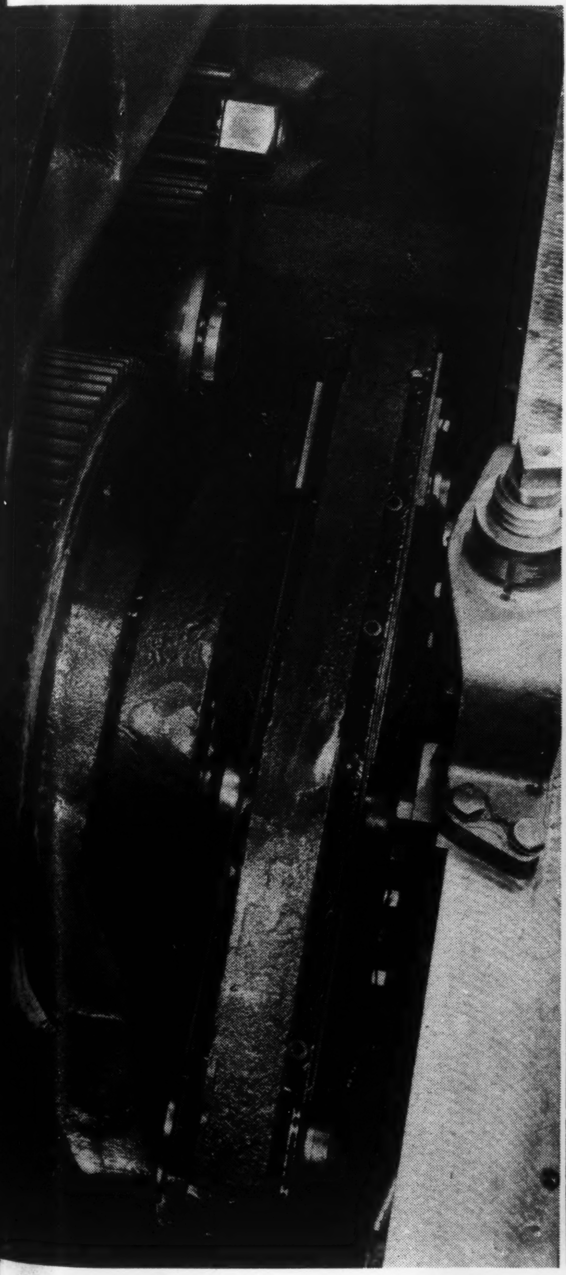
Fig. 1—Duplex rotary cut-off machine having a right-angle delivery. These cutters, driven by an ingenious double-crank mechanism, operate at line speed regardless of length of cut



RY CUTTER

ff and requires minimum setup time

By Chas. D. Nitchie
Chief Engineer
Samuel M. Langston Co.
Camden, N. J.

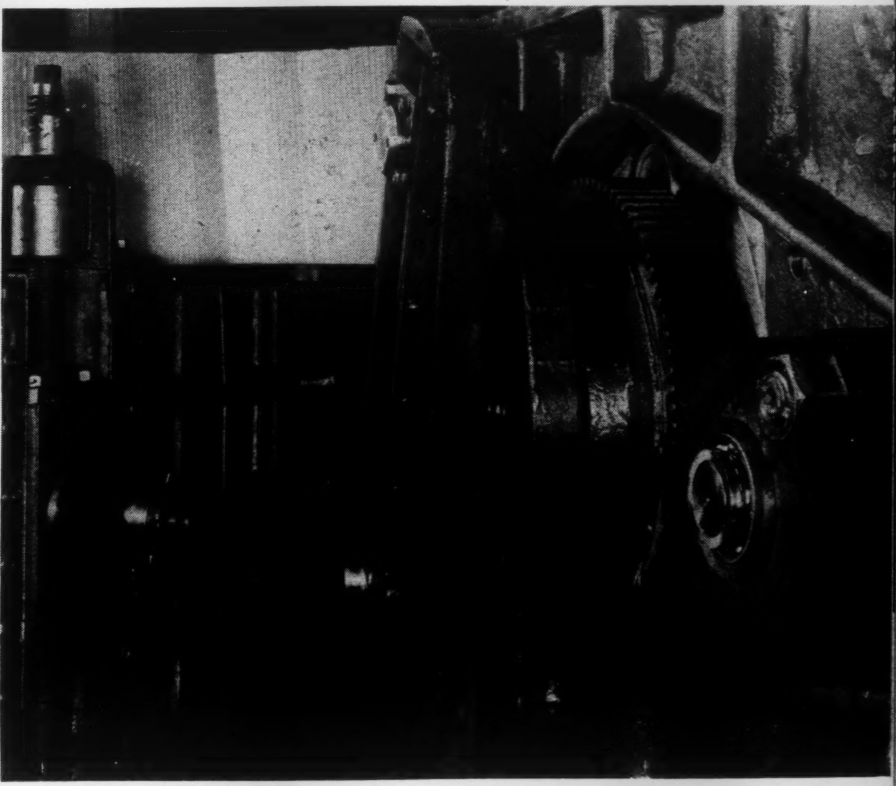


speed transmission could replace the gear box and maintain the same cut-off accuracy. This machine employed a Reeves transmission to establish the frequency of cut and the same elliptical differential to synchronize the knife with the paper speed.

As speeds increased, however, inertia forces again became a factor. For a time, this problem was alleviated by substituting aluminum arms and lightweight tubular heads for the moving parts. These improvements were satisfactory only to speeds about 350 feet per minute, necessitating development of a new cutter with reduced or balanced inertia forces. The rotary cutter shown in *Fig.* 1 is the result of this work.

Field experience and a better understanding of the

Fig. 2—Assembled view of knife accelerating mechanism and view with case open showing adjustable pivot block disengaged from the slide link. Adjustment of this pivot controls acceleration of the rotary knives



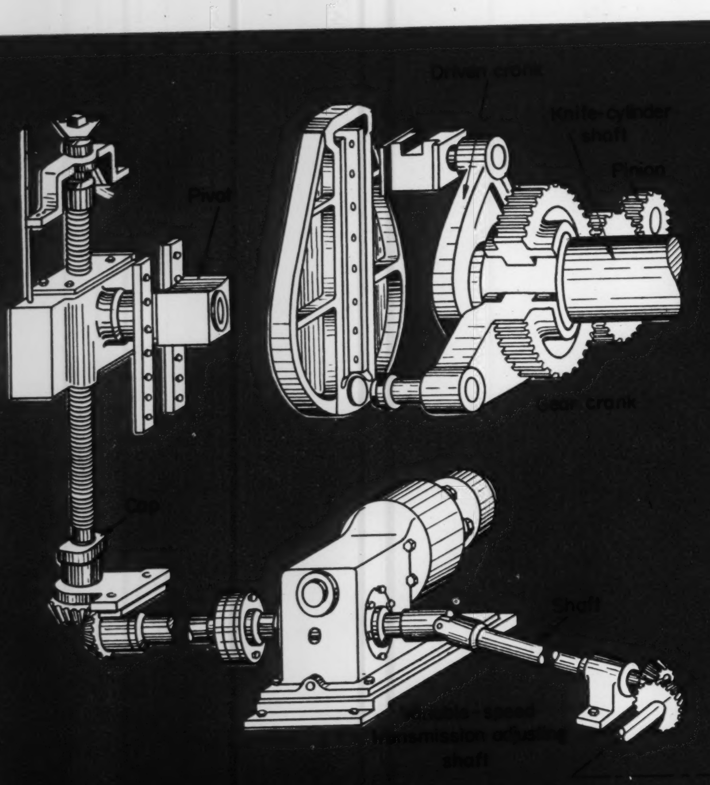

Driven crank
Knife-cylinder shaft
Pinion
Pivot
Gear crank
Cap
Shaft
Variable-speed transmission adjusting shaft

Fig. 3—Left — Schematic view showing how pilot gearmotor controls speed ratio of variable-speed transmission and pivot position of double-crank drive

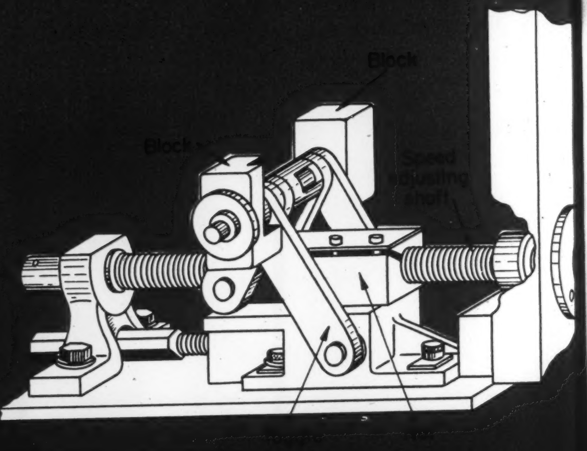

Block
Block
Speed adjusting shaft
Toggle
Rail

Fig. 4 — Above — Toggl linkage compensator on ad justing screw of variabl speed transmission to pro vide straight line outpu speed with respect to posi tion of screw. Blocks on t toggle pins operate in sli of the transmission adju ment rails

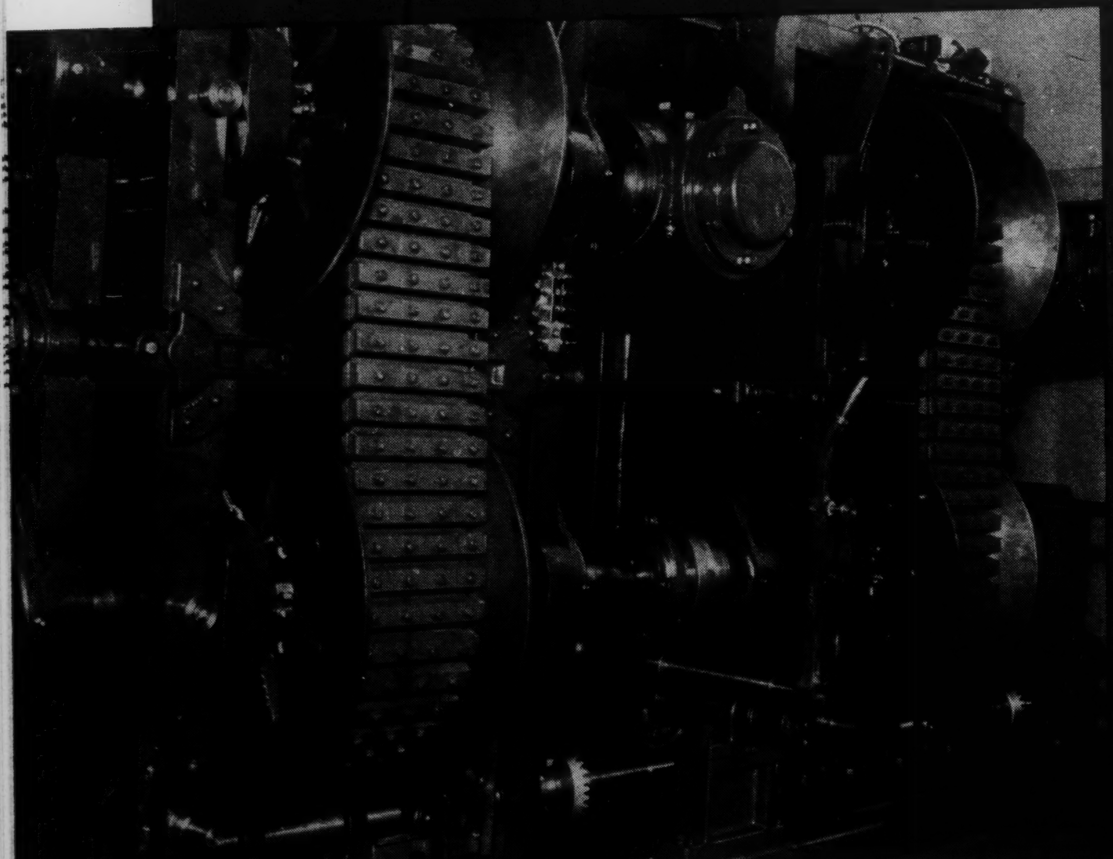


Fig. 5 — Left — Vari speed transmission hav toggle link compens on the adjusting rails each side of the sheave

problems resulting from faster cutting, indicated that a careful analysis was necessary to determine the best system. This analysis, research and experimentation led to the general conclusion that a drum type knife carrier would be the best form for reducing knife inertia. This would also give the greatest ratio of strength to weight for the rigidity required to span increased widths of paper board up to 115 inches. To obtain the proper type of shearing action would require two knife cylinders geared together to develop the proper action of the knife blades and, at the instant of cut, the knives should be travelling at line speed. To obtain various lengths of cuts, therefore, would necessitate accelerating or decelerating the speed of the knife cylinders before and after each cut, depending on the length of stock desired.

To determine the best type of acceleration control mechanism for the rotary knife, an independent study was made. It was desired that it be simple in construction, relatively small in size and capable of operating at high speed. The ingenious arrangement, employing a double crank and pivoted slide link, shown in *Fig.* 2, was developed.

Referring to *Fig.* 2 in the view showing the cover and pivot removed from its slide, the pinion in the foreground drives, through an idler gear, the main gear crank. The crank at the lower part of the illustration, being integral with this gear, has its pin journalled in one end of the slide link. The pin of the second or driven crank carries a slide block in the other end of the link. The shaft of the driven crank supports the bearing for the gear crank and passes through it to drive the bottom cylinder of the rotary knives. Its speed determines the speed of the cutter.

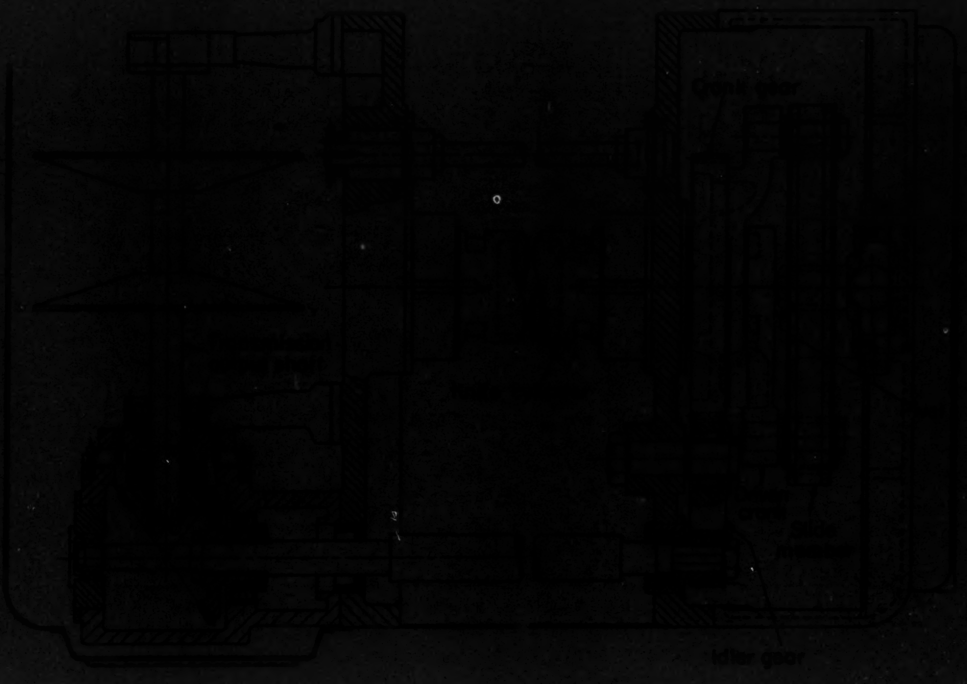
To provide adjustment for varying the cut length, the pivot is mounted on a screw in the frame of the cutter. Turning the screw displaces the pivot to give the change in acceleration relationship that is needed between the driving speed and the knife speed for each cut length. Inasmuch as the cranks are moment arms about the pivot, changes in pivot position alter the speed of the driven cut-off in direct proportion to the pivot position.

When the pivot block is in place in the slide link and is centered with the crankshaft, the rotation of all elements in the drive are constant with respect to each other. If the pivot block is lowered, however, the leverage between the cranks changes and a variable output motion results. When the block reaches the bottom position, the ratio of velocity about the pivot of the point of cutting becomes $5\frac{1}{2}$ to 1, producing the longest sheet length.

The parts of the accelerating mechanism are relatively small because of their direct action in the driving system. The slide link is the largest unbalanced member and, because it is aluminum, the drive has low inertia. This entire system is enclosed in a case and is oil bath lubricated.

To synchronize the cutter drive with the speed of the paper board web, it is necessary that the pivot block be in proper position. Because each change in cut length requires a change in speed of the driving gear crank, the pivot must be adjusted to vary the knife speed accordingly at the instant of cut. This is accomplished by the control system shown in *Fig.* 3. A double-shaft gearmotor, with a brake for holding

[illegible] plan view [illegible] showing [illegible] shaft [illegible] cylinder [illegible] crank mechanism



position, adjusts both the pivot block and a variable-speed Reeves transmission simultaneously. The output of this transmission drives the pinion, ***Figs.*** 2 and 3.

Input to the variable-speed transmission is through takeoff from the main drive of the process machines. Any change in the speed of the paper board web therefore is reflected in the speed of the transmission so that any cut length set on the rotary cutter produces a constant-length cut regardless of web speed. Output speed of the Reeves transmission determines the cut length and this is adjusted by the gearmotor control shown in *Fig.* 3.

Inasmuch as the speed of the knife blades at the time of cutting is a straight-line function with respect to the position of the pivot in the double-crank mechanism and the screw and gearing positioning for this pivot are also straight-line functions, the angular position of the gearmotor is likewise a straight-line function with respect to the speed of the cut. The speed control mechanism of the variable-speed transmission, however, approximates a second-degree curve.

To compensate for this difference in speed relations, a mechanism is incorporated in the transmission to make its speed ratio linear with respect to its adjusting screw and in turn to the gearmotor control. This compensating mechanism consists of the toggle linkage shown in *Fig.* 4. This linkage is so proportioned that, when one leg pin is fixed and the other travels with the nut on the adjusting screw, the center pin travels on a block in a slide on the transmission rail to provide a straight-line characteristic. This compensating mechanism is shown at the bottom of the rails on each side of the sheaves in ***Fig.*** **5.**

With this control arrangement and the pivot screw connected so that the pivot lowers with decreased speed of the transmission output, the speed of the cutter knives is always maintained at web speed during the instant of cut, regardless of change in cut length or in web speed. This feature is important for rapid and accurate change or reset in sheet length.

Details of the cutter drive are shown in *Fig.* 6. Bevel gearing on the variable-speed transmission output shaft drives the pinion (previously discussed) on the other side of the machine. Through an idler, this pinion drives the gear crank of the cutter mechanism. In this machine, one revolution of the machine driveshaft or the input shaft of the transmission is equivalent to approximately one foot of paper so that a tolerance of 1/32-inch in sheet length is equivalent to about one degree of slip, indicating the accuracy of the transmission.

Construction details of the double-crank mechanism, the knife cylinder drive and the speed adjustment control are shown in *Fig.* 7. The double-shaft gearmotor drives through bevel gearing both the variable-

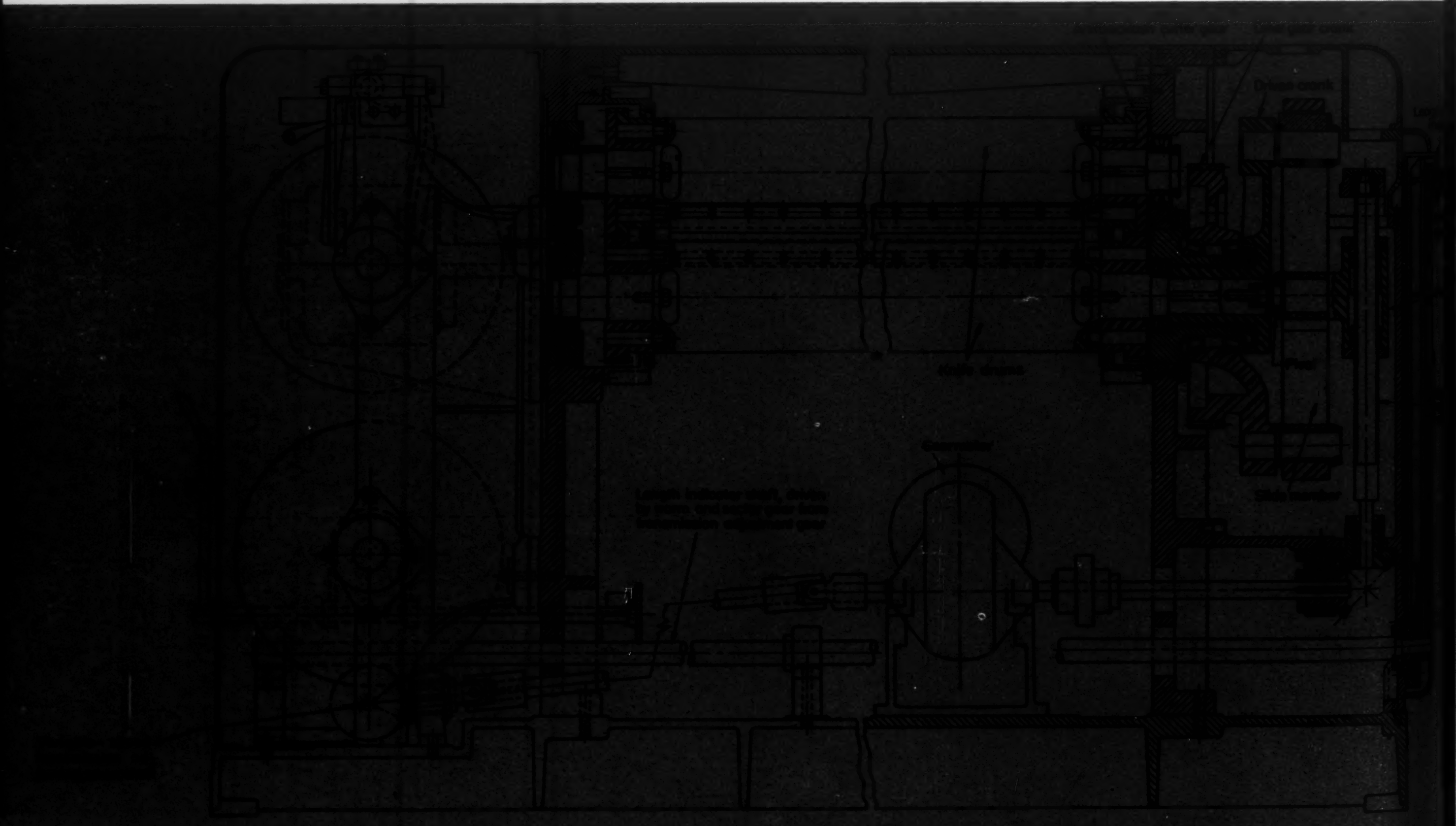


Fig. 7—Elevation section through machine showing gearmotor control of both output speed of transmission and pivot position of crank mechanism. Pivot position is always such that cutting action takes place at line speed regardless of speed ratio setting of transmission

speed transmission adjustment screw and the pivot adjustment screw in the double-crank mechanism. Also shown in this drawing is the driving arrangement for the knife cylinders. The lower cylinder drives the upper cylinder through antibacklash gearing, the upper gear being split to provide adjustment for taking up the backlash. Similar gearing at the other end of the cylinders maintains alignment of the blades and prevents deflections from interfering with the knife action.

Adjustment of the knife cylinders for proper cutting action is made by relative rotation of the cylinders relative to the gearing. The former are bolted to the gears through slots in the cylinders. Precise adjustment of the blades is provided by adjusting screws which clamp the knife blades as shown in the section through the cylinders in *Fig.* 8.

Indication of sheet length being cut may be observed at all times by viewing the pointer on an arc scale located on the side of the machine, *Fig.* 9. Also provided on this sector is a stop which may be preset. When the operator is ready for the next cut length, whether it be longer or shorter, he presses the proper pushbutton to energize the gearmotor control in the desired direction. As the pointer reaches the preselected position its arm contacts a precision limit switch on the preselector. This opens the circuit of the gearmotor and sets its brake to assure accurate positioning and preclude possible drifting during operation of the cutter.

Positioning of the indicator is taken from the adjusting screw of the transmission and may be seen in *Fig.* 5 between the two transmission units as a worm and gear sector takeoff. *Fig.* 7 shows this length indicator shaft traveling across the machine to the indicator arm at the right of the double-crank mechanism. In addition to the limit switch on the preselector, limit switches are also utilized for both the acceleration control system and the transmission so that damage cannot be done to any part of the mechanism.

Paper board processsing machines with which this cutter is associated, are driven mainly by Reliance variable-voltage drives, having an 8 to 1 speed range and providing a top speed of 500 feet per minute. At any operating speed within this range, the cut-off cleanly cuts sheets of uniform length within a tolerance of plus or minus 1/32-inch from a minimum sheet length of 34 to a maximum of 187 inches. Development of this machine has taken the problem of cutting off the critical list of limitations for high-speed production of corrugated paper board.

In addition, the machine has reduced setup time to a minimum. With its synchronized control system and preselector, the time required during changeover is little more than that required for pressing a pushbutton.

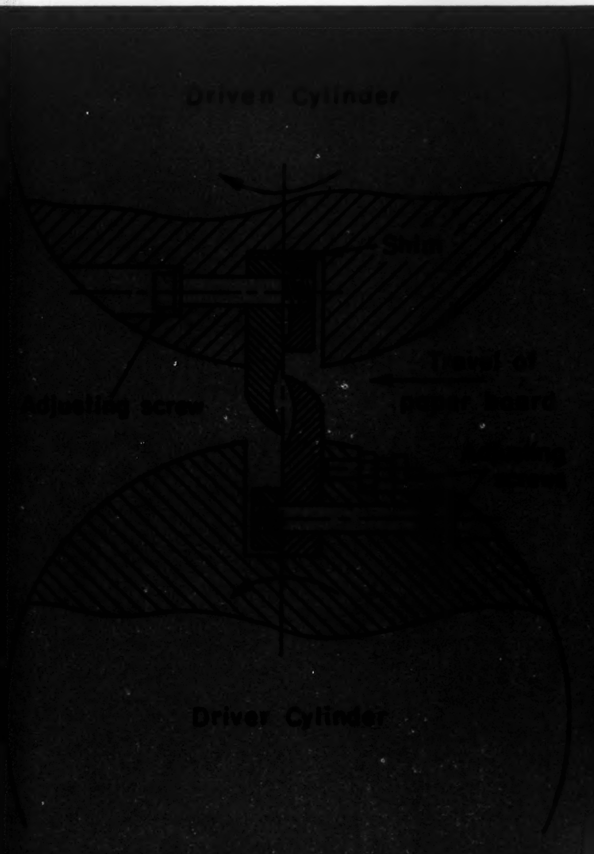


Fig. 8—Section through knife cylinders in cutting position. At this position the blades always travel at the speed of the paper board web

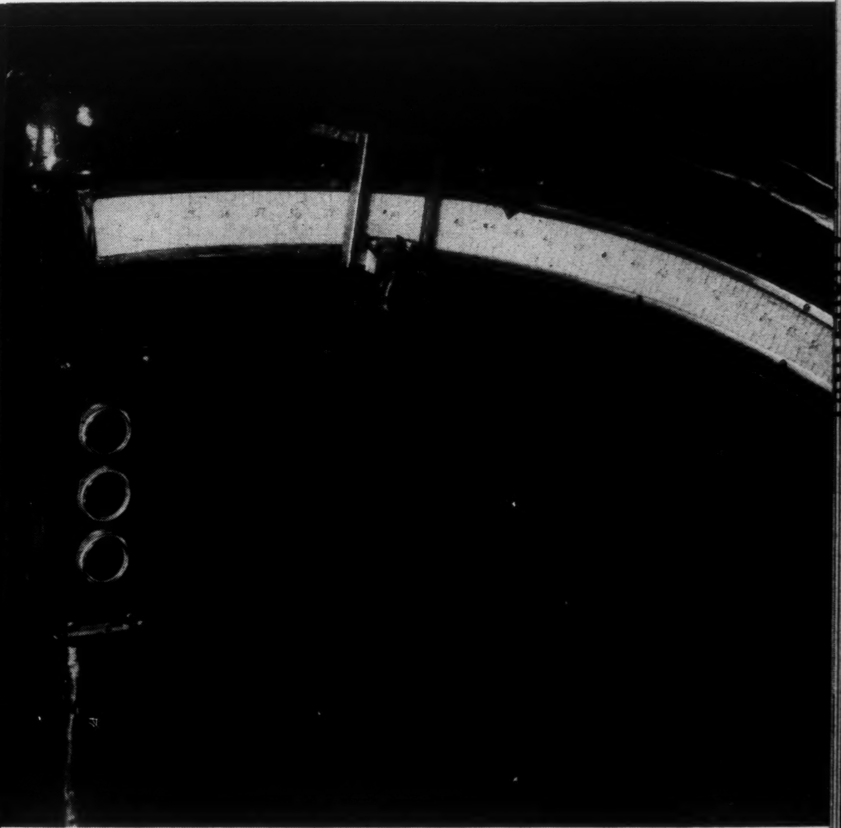
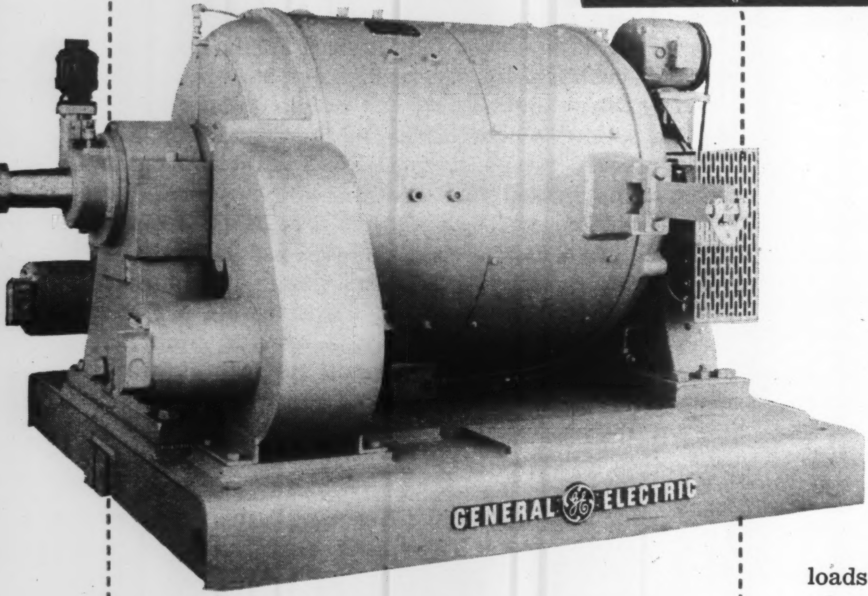


Fig. 9—Preselector and length indicator. Preselector may be set at any time during run. When new cut length is desired, operator pushes button and machine adjusts itself automatically to new length

HYDROSTATIC BE



By P. S. Potts

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Break an aspirin tablet into four parts. The weight of just one of these pieces—less than 0.00025-pound—is enough to rotate the 1300-pound cradle of the dynamometer in the picture. This and other impressive results, including reduction of bearing friction coefficient to less than 0.00000075—about one-thousandth of the least coefficient possible with conventional bearings, were attained with hydrostatic bearings. Outlined in this article is one method of applying this low-friction type of bearing

RELATIVELY simple in construction, hydrostatic bearings can reduce friction to an absolute minimum in slowly moving or rotating bearing assemblies. In a support bearing, radial and axial stability can be provided, along with movement through small angles of rotation. Heavy rotating parts can be raised while stationary in order to reduce starting torque below the normal high breakaway torque of a heavily loaded journal bearing. On machine tools, hydrostatic bearings permit heavy loads to be supported on ways with a high degree of radial rigidity, free movement parallel to the ways, and no motion normal to the direction of the ways.

As a practical example, this article shows how the unique advantages of the hydrostatic bearing principle were applied in the design of a cradle dynamometer. Here the requirement is extremely low friction at zero rotational speed, a difficult condition for which the hydrostatic bearing is eminently suited.

Advantages: The dc absorption dynamometer is essentially a dc generator having field and stator parts cradled to permit the electromagnetic reaction between the armature and stator to be transmitted to a force-measuring device, which prevents the stator from rotating. Usually this cradling is accomplished by supporting the generator stator on antifriction trunnion bearings, mounted in the two pedestals. The only appreciable error in torque measurement with such equipment is caused by (1) friction in the electrical and mechanical connections, (2) power required to drive uncradled auxiliaries, (3) trunnion bearing friction.

Although error from the above causes is usually insignificant when measuring full-load torque of equipment, the errors are more or less constant. Thus, at low torque the error becomes a relatively large part of measured values. Minor changes can be made to reduce the first two of the above sources of error. The hydrostatic bearings, *Fig.* 1, offer a means of reducing error from the third source.

In the hydrostatic bearings the load is supported on a continuous film during operation, eliminating any possibility of metal-to-metal contact. Low-voltage detector devices can be employed to indicate when the bearings are functioning properly. Most important, the hydrostatic bearing has insignificant friction when the stator is stationary, as it must be for a dynamometer scale to be read.

INGS . . . minimize friction in cradle dynamometer

Factory tests on the dynamometer show it to be sensitive to an unbalanced weight of less than 0.00025-pound placed on the dynamometer torque arm. The improvement over more common types of trunnion bearings is better appreciated by comparing this sensitivity with that of other bearings, for which a coefficient of friction of 0.001 is regarded as low. The corresponding coefficient of friction for the hydrostatic bearing is less than 0.00000075 for the least sensitive unit built to date. And, in addition, the familiar problem of brinelling in stationary or slowly oscillating rolling-contact bearings is virtually eliminated.

Principle of Operation: The hydrostatic bearing which appears to satisfy dynamometer requirements of stiff axial and radial stability best is the spherical bearing shown schematically with its associated equipment in *Fig.* 2. Oil film pressure supporting the journal load in a normal rotating journal bearing is created by the rotation of the journal; however, pressure for the stationary hydrostatic bearing must be supplied by external means consisting of a pump and pressure-regulating valve. In other respects, the hydrostatic bearing operates in much the same manner as the more familiar hydrodynamic journal bearing except for the action of the restrictors and pressure pads, which are included to provide radial and axial rigidity. Oil or other comparable liquid is supplied to the pressure pads at a regulated pressure great enough to lift the journal load. Pressure required for the bearing is kept within reasonable limits of approximately 200 to 300 psi by proper selection of the pressure pad area and the leakage area from the pressure pad to atmosphere. For oil film thicknesses under the journal of approximately 0.002-inch, moderate pressures of this magnitude reduce the pump motor requirements to reasonable values when liquids are used as the lifting media. The use of gas or air for this purpose is not practical when the load to be supported is appreciable because of the high power losses resulting from compression of the gas without any useful work being accomplished during expansion. A low viscosity compressible fluid, however, could be useful for lightly loaded hydrostatic bearings where pumping costs are not important, and friction must be reduced to an absolute minimum.

Rigidity in the radial and axial direction is accomplished automatically. Restrictors for the hydrostatic bearing are selected to produce a relatively high pressure drop through the restrictor, approximately

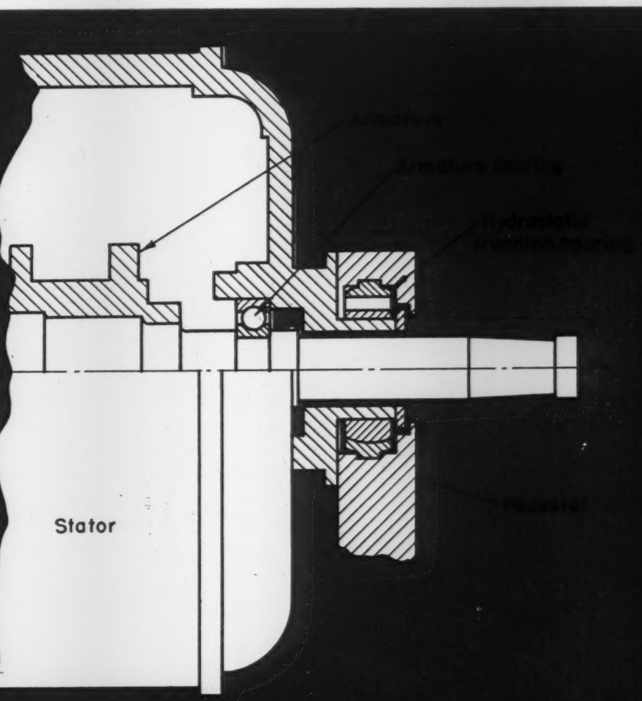


Fig. 1—Conventional trunnion bearings on this typical dynamometer have been replaced by hydrostatic bearings to minimize friction

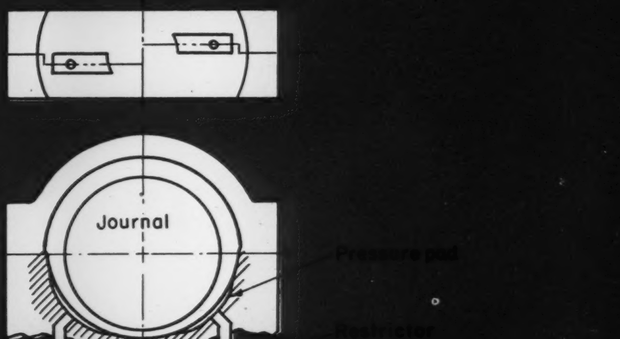


Fig. 2—Oil flow diagram in the hydrostatic bearing, showing how external oil pressure "lifts" the journal

equal to the pressure drop through the bearing. When the center of the journal moves to right of bearing center, *Fig.* 3, the cross-sectional area of the flow path from the left pressure pad to the atmosphere is increased, causing an increase in flow through this path and a momentary drop in pressure in the left pressure pad. With a lower pressure in the left pad, oil flow and pressure drop through the left restrictor momentarily increase. Since both the right and left flow paths are supplied at the same regulated pressure, supply pressure to the left restrictor cannot increase, and must remain equal to the supply pressure to the right restrictor. Thus, with a greater pressure drop in the left restrictor, pressure in the left pad remains below that of the right pad. This difference in pressure between the pads results in an unbalanced force on the journal, returning it to the central position where pressure-pad forces and oil flow are balanced. Axial stability is achieved in the same fashion by offsetting the pressure pads axially as shown in *Fig.* 2.

Besides providing radial and axial stability, properly designed restrictors maintain a constant oil film thickness under the journal as the oil temperature and oil viscosity change during operation. Uniform film thickness eliminates any change in the height of the shaft during operation, and prevents possible change in alignment between the cradled unit and other units which might cause vibration difficulties.

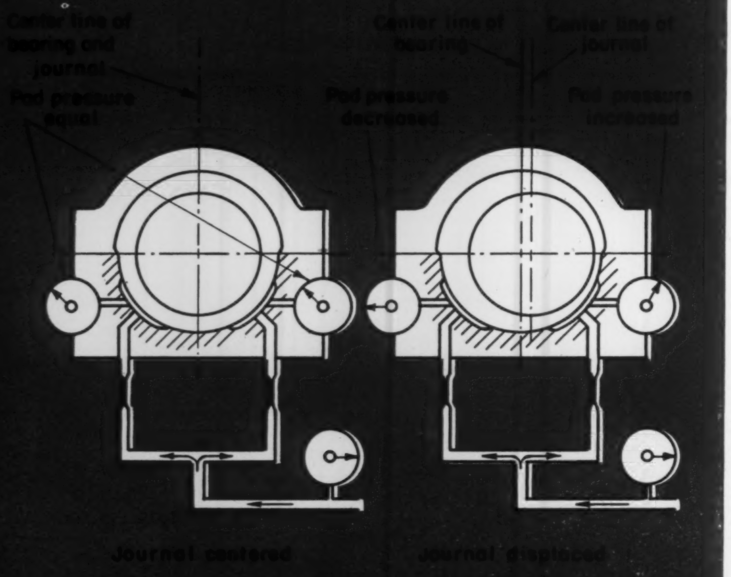


Fig. 3—When displaced, the journal is automatically returned to a centered position by forces resulting from changes in pad pressure

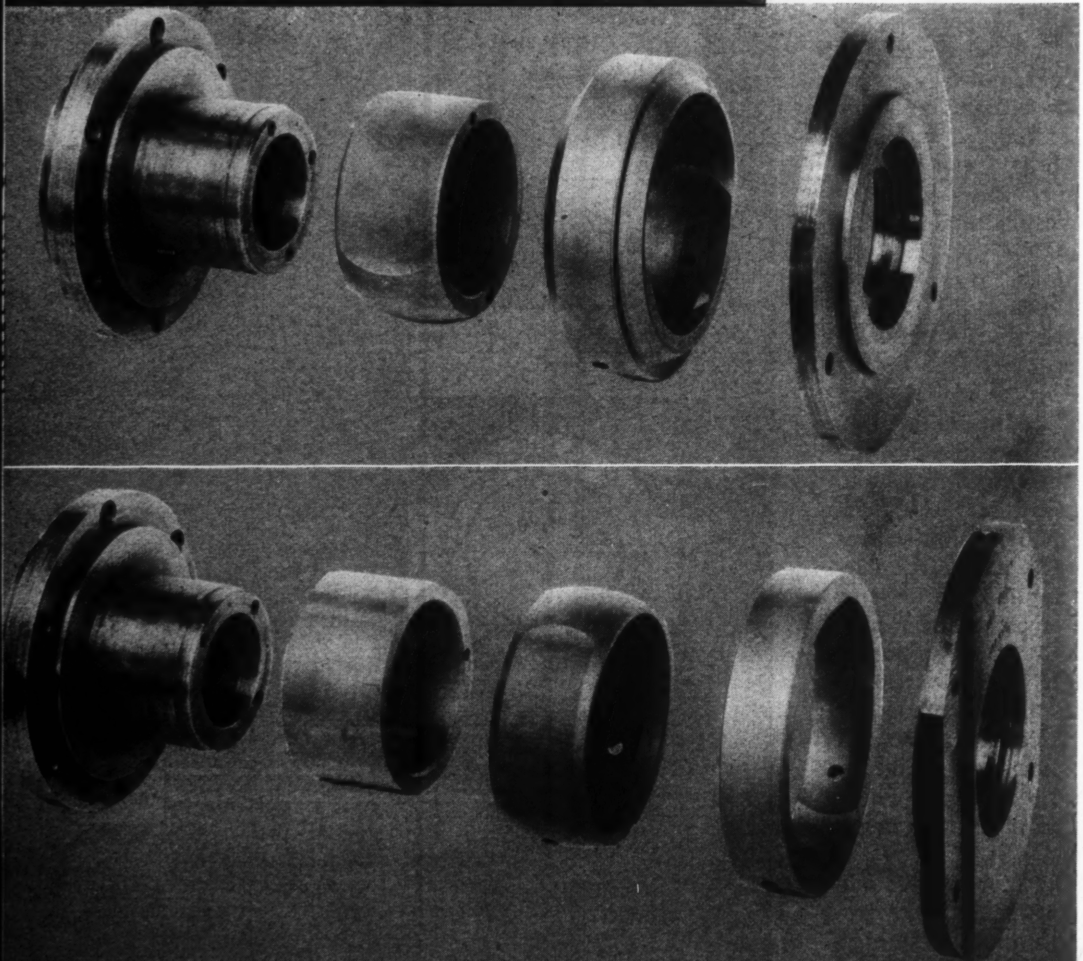


Fig. 4—Hydrostatic bearings for both ends of the stator. Spherical bearing at *a* includes the trunnion nose, rotating spherical journal, stationary spherical bearing with pressure pads, and mounting flange. Cylindrical bearing at *b* includes the trunnion nose, cylindrical journal and stationary bearing, self-aligning support ring and mounting flange

Analysis: In order to comprehend the action of the restrictor in maintaining a constant film thickness, quantity of fluid flowing from the pressure pad through the bearing to atmosphere must be investigated. This equation for flow, if the bearing is in its centered position, can be considered as analogous to the equation for viscous flow between parallel plates (see Nomenclature):

$$Q_p = K_1 \frac{p_p h^3 w}{\mu L}$$

Width of the leakage path from the pressure pad to the atmosphere for a particular bearing is a function of the radius, so the equation becomes

$$Q_p = K_2 \frac{p_p h^3 r}{\mu L} \qquad (1)$$

If the restrictor is a properly designed viscous restrictor, with a length several times its diameter, flow through it is equivalent to viscous flow through a pipe, for which the equation is

$$Q_r = K_3 \frac{D^4 p_r}{\mu l}$$

For the particular restrictor, the diameter and length are constant and can be combined in the constant, K_4, making the equation

$$Q_r = K_4 \frac{p_r}{\mu} \qquad (2)$$

Since flow through the restrictor and the bearing must be equal, Equations 1 and 2 can be combined:

$$K_2 \frac{p_p h^3 r}{\mu L} = K_4 \frac{p_r}{\mu}$$

Journal radius and length of the leakage path are constant for the bearing and can be combined in the constant, K_5. Furthermore, viscosity in the restrictor and bearing are essentially the same, so that this equation becomes

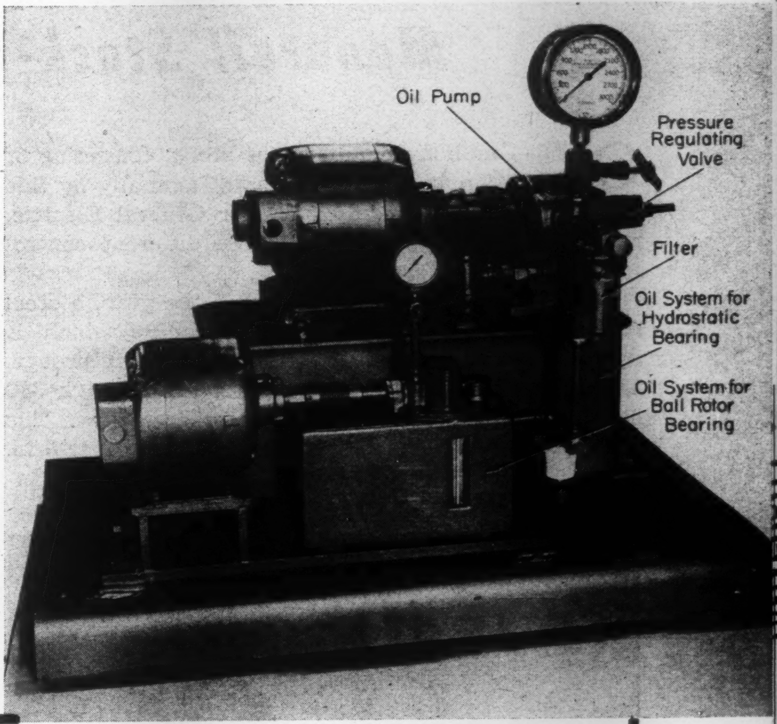
$$p_p h^3 = K_5 p_r$$

Since pressure drop through the restrictor is simply the difference between the regulated supply pressure and the pad pressure, this equation can be rearranged to show the film thickness

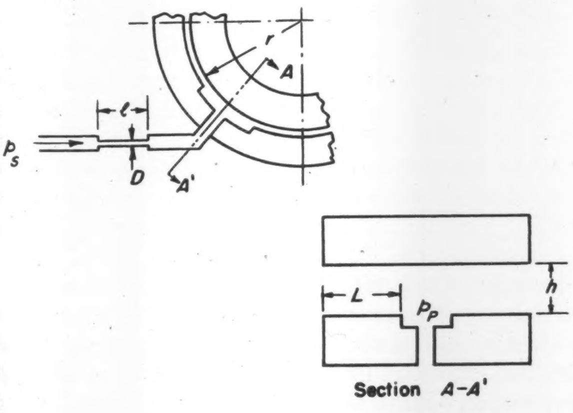
$$h = K_5 \left(\frac{p_s - p_p}{p_p} \right)^{1/3} \qquad (3)$$

Pad pressure is dependent on the load to be supported and the bearing geometry as mentioned previously. Hence, when the load is constant, the pad pressure, p_p, will be constant for any particular bearing. Since the oil supply is regulated to maintain a constant supply pressure, the oil film thickness, h, in Equation 3 remains constant during operation regardless of temperature and viscosity variations. The principle of the hydrostatic bearing may be applied to any desired configuration to obtain the re-

Fig. 5—Oil supply for the dynamometer bearings is handled by two separate systems, one for the hydrostatic bearings, and one for the armature bearings


Oil Pump
Pressure Regulating Valve
Filter
Oil System for Hydrostatic Bearing
Oil System for Ball Rotor Bearing

Nomenclature



D = Inside diameter of restrictor
h = Oil film clearance
K_1, K_2, K_3, K_4, K_5 = Constants
l = Length of restrictor
L = Length of leakage path from pressure pad to atmosphere
p_p = Pressure in pressure pad
p_r = Pressure drop through restrictor, $p_s - p_p$
p_s = Regulated supply pressure
Q_p = Rate of flow from pressure pad to atmosphere
Q_r = Rate of flow through restrictor
r = Radius of journal
w = Width of leakage path from pressure pad to atmosphere
μ = Dynamic viscosity

quired direction of load support with the same basic elements and operation.

Design Consideration: The dynamometer is supported by the two hydrostatic bearings shown on the exploded photograph, *Figs.* 4*a* and *b*. Both bearings have self-aligning features. The spherical bearing, *Fig.* 4*a*, supports the axial load on the dynamometer as well as radial load. The other bearing of the pair is cylindrical to permit axial movement of the journal and bearing to accommodate differential thermal expansion of the dynamometer stator and base. It will be noted that the spherical elements have been designed as solid pieces rather than being split as is usually done for spherical assembly. Assembly is made by rotating the mating pieces to engage, and then returning the pieces to their proper operating position after they are together. Also apparent in *Figs.* 4*a* and *b* are the rabbet plates which are bolted to the dynamometer trunnion nose for mounting tachometer and feedback-generator auxiliaries. These devices are thus cradled on the dynamometer stator frame, eliminating them as a source of dynamometer error.

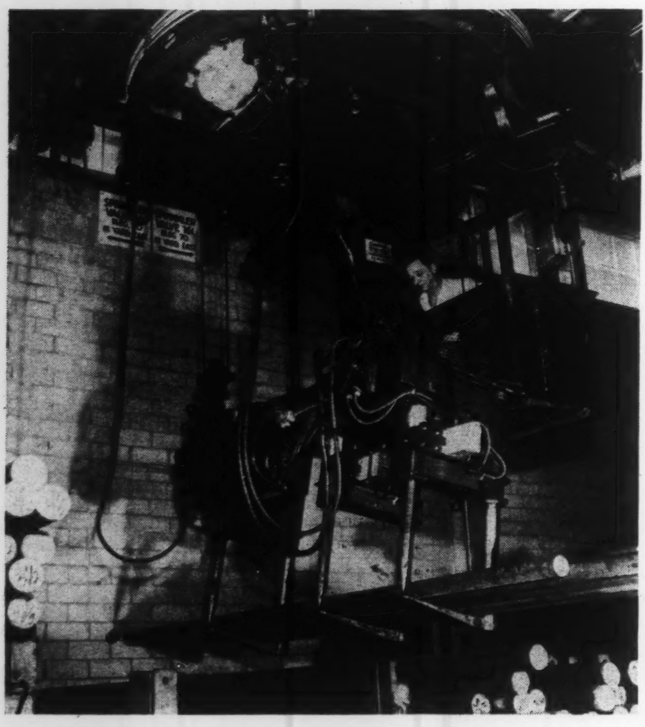
Lubricant for the hydrostatic trunnion bearings and the antifriction armature bearings is supplied by the oiling system shown in *Fig.* 5. The pump and oil supply are mounted remotely, and the oil is piped to a junction box on the dynamometer base where it is fed to each pedestal. Oil for the separate pressure pads in each pedestal splits at the bottom of the pedestal. The viscous restrictors are designed so that they may be removed for cleaning easily without any disassembly of the oil connections.

The relatively simple construction of hydrostatic bearing, its long life characteristics, and the results attainable with it in reducing friction indicate that more widespread use might be expected. The field of application of the hydrostatic bearing as a low-friction support certainly does not appear to be limited to the realm of highly special equipment.

Monorail Stock-Transferring Crane

OVER 4 million pounds of bar stock, consisting of 800 different sizes, are handled annually by this versatile crane. Specially built for General Electric, the 3-ton capacity unit uses seven different control functions in transferring stock.

Main element of the equipment is the grab, a steel frame suspended by pulleys and cables, which is equipped with three movable forks and safety prongs. The operator's cab and grab can rotate through 360 degrees, and travel longitudinally or crosswise. The grab can travel vertically from one inch to 9 ft 6 in. above floor level, and tilts from 8 degrees forward to 12 degrees backward. Forks and prongs rotate 90 degrees, and the prongs can be raised and lowered. Through reduction in floor space requirements for storing the bar stock—about 50 per cent—total cost of the installation was recovered in three years.



Cold-Weather Lubricants

FOUR new synthetic lubricants have been developed by the Navy to help prevent jamming of 20-mm aircraft guns at low temperatures. Lubricants used must not stick or jam the gun mechanism at temperatures from 170 F down to −70 F. Auxiliary heaters have been necessary below −20 F to maintain a constant rate of firing, but with the new lubricants, one application suffices at all temperatures.

Two of the lubricants, a light oil derived from adipic acid and a synthetic polyether grease, derived from natural gas, are required for periodic lubrication. The light oil lubricates the gun mechanism, and the grease is for the ammunition. Two other lubricants, an oil for the electric trigger mechanism and a grease for use in an automatic feeder, suffice for the life of the gun, and consist of silicones with minor chemical additives and a compound derived from sebacic acid, respectively. Both the adipic and sebacic-acid greases contain high-boiling alcohols derived from petrochemical sources.

Several other lubricants have been developed as part of the Naval Research Laboratory's program in synthetic lubricants. A series of synthetic diester oils, for example, have proved useful in bomb sights, gyroscopes, compasses, synchromechanisms, fire-control computers and aerial photographic equipment.

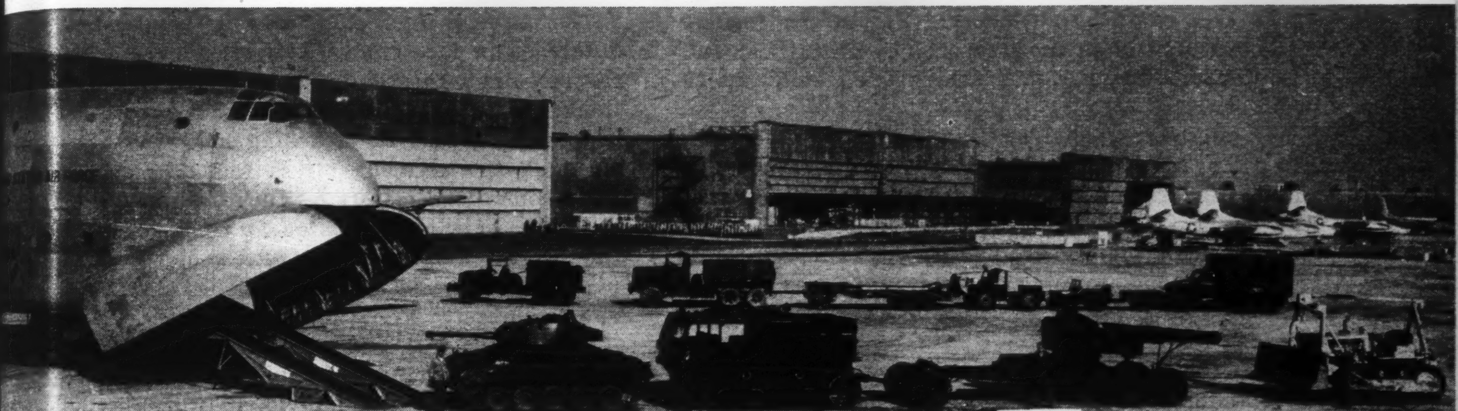


Fig. 1—Top—Panorama view of the C-124A airplane showing the different types of cargo which had to be considered in the design of the cargo floor

LIGHTWEIGHT

Stiffened Sections

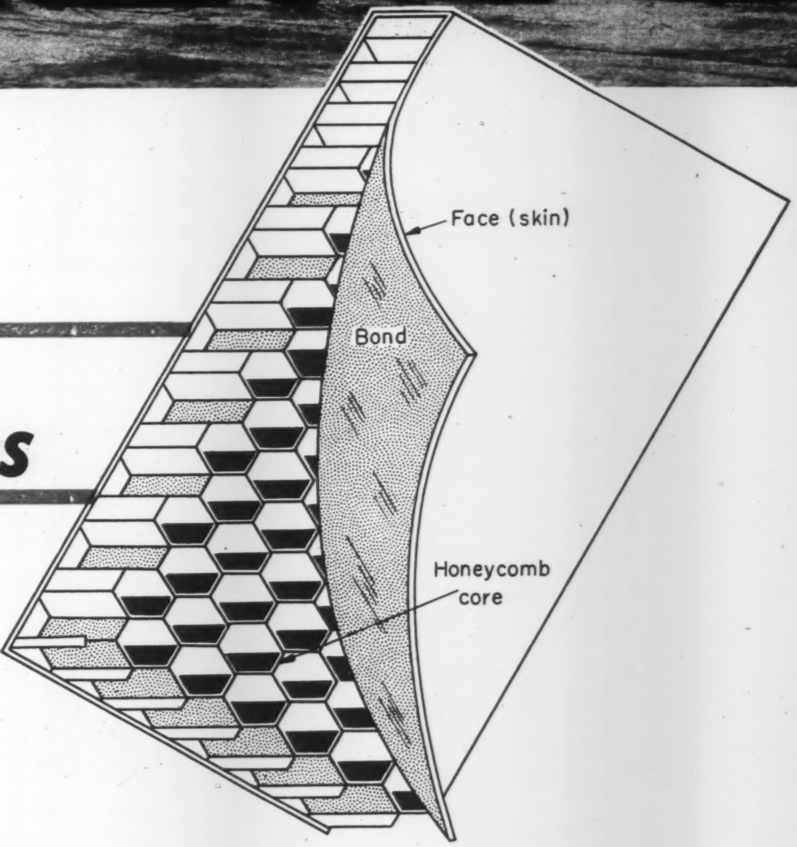


Fig. 2—Above—Sandwich type material considered. An adhesive is utilized to bond faces to honeycomb core

Materials evaluation and design considerations for lightweight high-strength sections utilized in developing a special aircraft cargo floor

By Melvin Stone
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FOR modern aircraft, the design of each structural component must be considered separately with regard to its particular function. The ultimate objective always is to achieve the lightest construction possible. As a method of approach to these problems, analysis and evaluation of several feasible designs at the preliminary stage have been especially effective in the development of the components of the C-124A transport airplane. Design of the cargo floor illustrates how this method was applied in evolving a lightweight, high-strength floor which would meet the performance requirements of a macadam roadway.

One of the primary missions of the C-124A transport is to supply the fighting zone with low, medium and high-density cargo of all types, *Fig.* 1. In the preliminary stages of the cargo floor design, it was necessary to consider the heaviest and most concentrated cargo or vehicle loads as well as load factors, so that representative floor structure and covering could be ascertained. Primary loadings to be considered were: (1) Uniform loading of 42,000 pounds

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[1] References are tabulated at end of article.

on an area of 16 by 20 inches; (2) uniform loading of 35,000 pounds on an area of 7 by 15 inches; and (3) uniform loading of 21,000 pounds on 8 by 20 inches.

For purposes of analysis the floor was divided into two parts; substructure and floor covering. Substructure or underneath floor structure was the most critical because other factors, such as bulkheads and frame spacing, depended upon it. Tests and theoretical calculations were used to evaluate the various preliminary designs.

Floor Substructure: First consideration was given to an adhesive-bonded sandwich construction which would act as both the substructure and floor covering. This construction, consisting of a multilayer skin having thin, high-strength faces with a low-density core of honeycomb material, is shown in *Fig.* 2. The faces carry the major part of the loads while the core increases the stiffness of the section, keeps the faces from deflecting independently and stabilizes them against buckling. The function of the bond is to attach the faces to the core and also withstand the tensile, shear and crushing loads imposed. If the correct adhesive is used, glue failure will take place when the stresses in the metal approach ultimate, that is, the failure of the adhesive is determined by the elongation of the metal.[1,2,3]

Two thicknesses of panels, five and ten inches, were investigated. These panels were attached at the sides of the fuselage and supported occasionally by bulkheads below the floor. For the five-inch thick panel, 0.250-inch 24ST Alclad faces with an aluminum honeycomb core were used having a weight of approximately 9 psf. The ten-inch panel required only 0.102-inch 24ST Alclad faces on the aluminum honeycomb core, reducing weight to approximately 6½ psf.

The ten-inch thick panel was lighter because of the difference in face thicknesses—the loads imposed on the faces is a function of the panel thickness. Sheet thickness of the aluminum honeycomb core remained the same because the crushing load was not altered although the shearing stress was decreased. Other honeycomb core materials, such as paper and fabric sheeting, were contemplated as a means of reducing the overall weight of the panels, but an aluminum honeycomb core was necessary due to its high shear and compressive strength.

Continuing with the investigation of feasible floor substructures, the use of transverse beams across the fuselage, connected to individual frames as shown in *Fig. 3a,* was considered. Beams were placed approximately twenty inches on center to match the frame spacing. These beams consisted of 75ST extruded caps with 0.125-inch 75ST Alclad webs and weighed approximately 3¼ psf.

Use of longitudinal beams was examined but it was quite obvious that such beams could not be extended throughout the entire length of the floor and keep the weight reasonable. To supply the necessary support, transverse bulkheads to redistribute the loads to the side of the fuselage, were used as in *Fig.* 3*b*. These bulkheads were incorporated with the frames to which the hoist rails, for carrying the traveling crane, were attached.

The frames utilized had been designed to occur at approximately every one hundred inches. For a weight-strength investigation the caps of the longitudinal beams were made continuous across the bulkhead. With beams placed approximately twenty inches apart, and including the transverse bulkheads, total weight was approximately 2⅝ psf.

This concluded the preliminary analysis of the substructures. The next step was to evaluate all floor

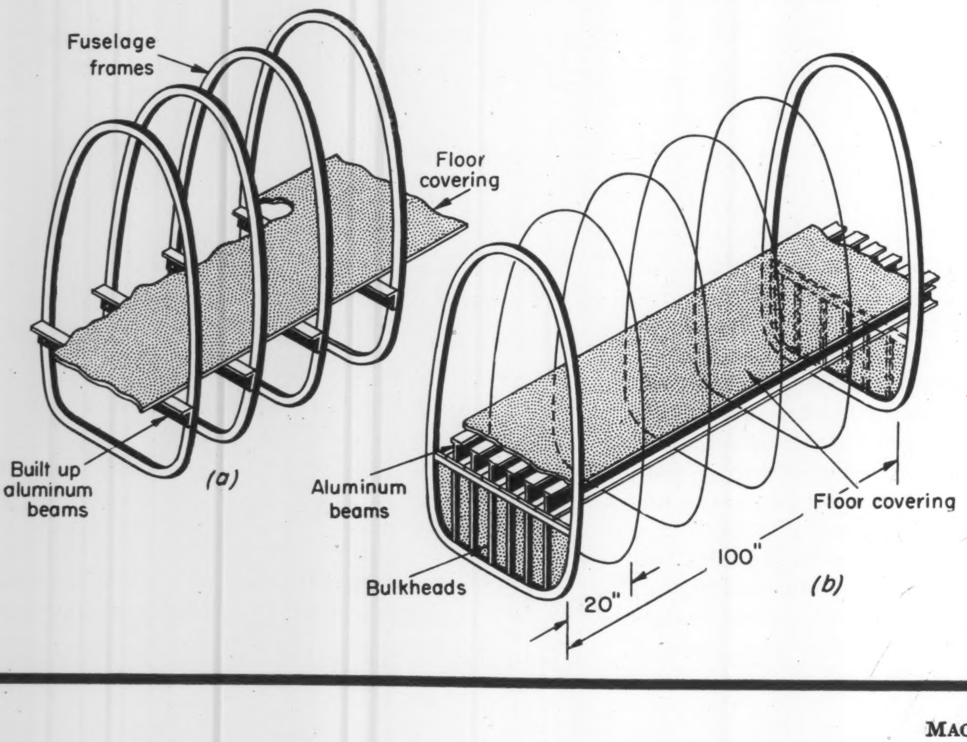


Fig. 3—Types of substructure considered for the cargo floor construction Transverse beams *a* connect to individual frame while longitudinal beams *b* are supported by bulkhead

Table 1—Floor Covering Constructions and Weights

Type of Construction	10-Inch Beam Spacings		20-Inch Beam Spacings	
	Materials	Weight (psf)	Materials	Weight (psf)
Sandwich	0.064-in. 24ST Alclad faces, aluminum honeycomb core	2⅝	0.156-in. 24ST Alclad faces, aluminum honeycomb core	5¼
Stiffened skin	0.072-in. 75ST Alclad skins, corrugated aluminum-alloy core	3	0.102-in. 75ST Alclad skins, corrugated aluminum-alloy core	4¼
Plywood	0.695-in. thick, 9-ply, birch skin-yellow poplar core	2¼	1$\frac{1}{16}$-in. thick, 14-ply, birch skin-yellow poplar core	4¼

covering possibilities. In this way, a combined analysis of the two components, covering and substructures, would permit a choice of the best construction for weight and strength.

Floor Covering: Examination of the floor covering was based on the use of beams spaced either ten or twenty inches apart. Thickness of floor covering was not to exceed one inch in order to allow space below the floor for equipment items. The various floor constructions considered are shown in TABLE 1.

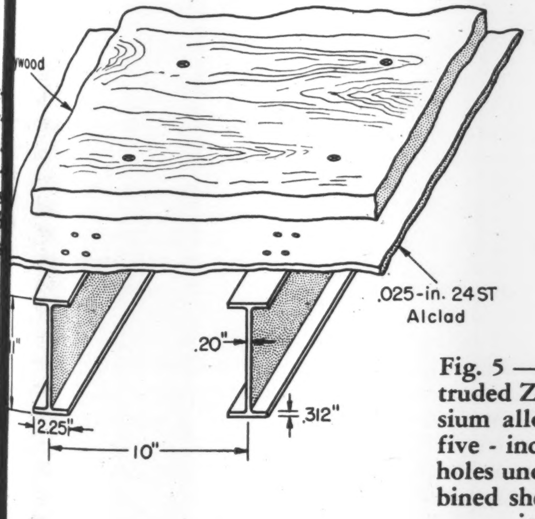
From the study made of sandwich construction for floor covering, it was found that excessive shear loads necessitated using higher strength core sheeting than was available at the time. Thus, in TABLE 1 this material has been estimated for weight comparison purposes only.

Stiffened skin constructions were aluminum-alloy hat sections or corrugations attached to aluminum-alloy skins. This construction, as well as the sandwich construction, transmits the bending load to the adjacent beams.

Plywood was the final floor covering material to be considered. Birch-yellow poplar was employed because it seemed to possess the strength qualities that were best suited. This type of construction was different from the other types of coverings considered in that the plywood acted as a membrane to distribute the loads to the adjacent beams.

Design Evaluation: Using the information obtained from these preliminary analyses it was concluded that the lightest construction would be the longitudinal beam substructure at 10-in. spacing with a birch-yellow poplar plywood covering. Although the ten-inch thick sandwich construction was favorable from a weight-strength standpoint, other factors were not as good. The longitudinal beam substructure with plywood covering would be easier to replace and less expensive. Also, it could be adapted more readily

Fig. 4—Below—Alclad sheet added between plywood and beams acts as a diaphragm to keep flexure stresses to a minimum



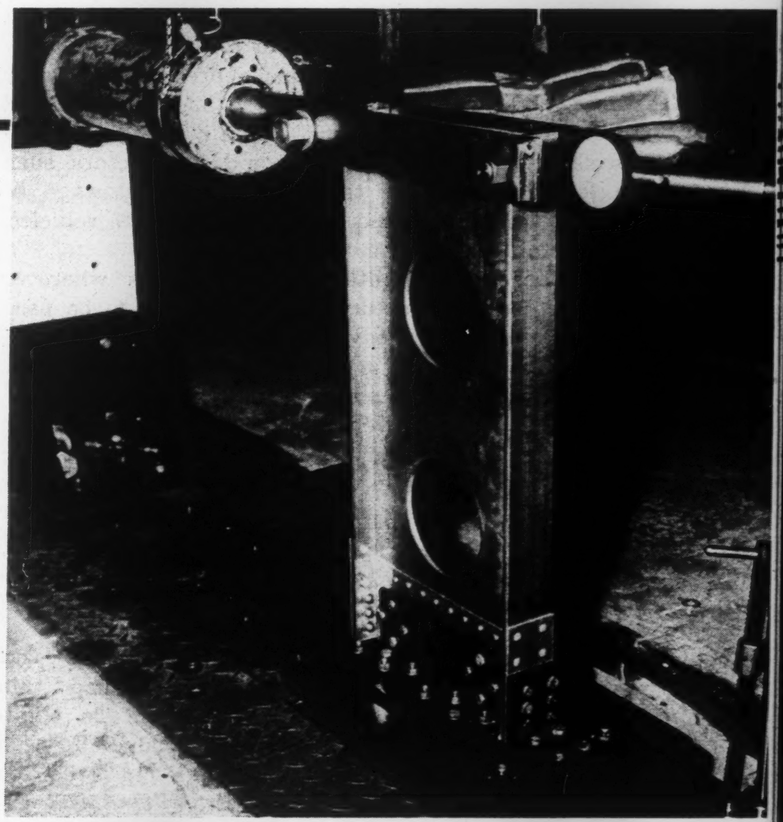


Fig. 5 — Right — Extruded ZK60A magnesium alloy beam with five - inch lightening holes undergoing combined shear and bending tests

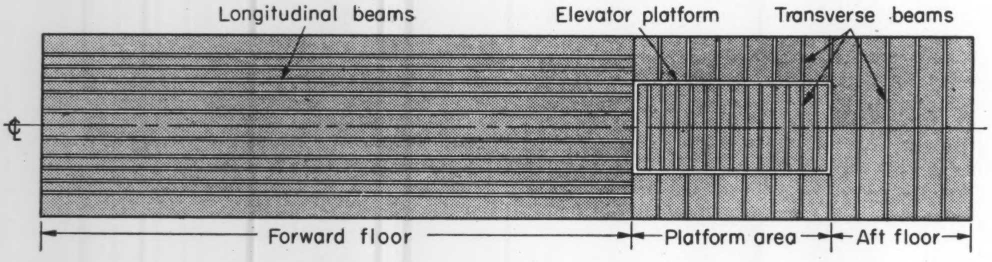


Fig. 6—Diagram of cal floor showing the thr main sections; forwa platform and aft

for attaching tie-down fittings and making necessary cutouts.

With the floor construction selected it was necessary to establish the exact strength of the plywood covering by a strength test. In the first tests the 0.695-inch plywood failed in combined shear and bending at lower loads than were comtemplated. To add strength, 0.025-inch 24ST Alclad sheet was placed below the plywood and attached to the longitudinal beams at approximately ten inches on center, *Fig.* 4. This permitted a decrease in plywood thickness from 0.695 to 0.460-inch, the Alclad sheet supporting the plywood continuously and acting as a diaphram to keep flexure stresses to a minimum. Final plywood selection was birch with a spruce inner core. The weight of the 0.460-inch plywood plus the 0.025-inch web was approximately 2 psf—a saving in weight over the 0.695-inch plywood.

To establish floor design criteria, compartment ratings and maintain the center of gravity of the airplane, data on the vehicles to be carried had to be obtained. Models to 1/32-scale were made for all vehicles listed in *Technical Data for Army Air Force Equipment* as well as for other representative loads. These models were placed on a 1/32-scale floor and fuselage drawing in order to obtain the desired information. From this data, floor design factors, such as location of cargo tie-down fittings, stowage of vehicles and cargo, and rolling positions of vehicles, were established.

To permit the lightest floor members wherever possible, heavy structural members were to be used under the areas of heaviest load. Based on information derived from scale models, it was decided to use two treadway areas, which would support the maximum loaded stowed vehicles, running the full length of the fuselage. This established a floor construction having longitudinal beams spaced approximately 10½ inches on center in the track area. In the center floor area lighter beams spaced farther apart and having thinner plywood covering were used. Beams in the center area were kept far enough apart to allow egress below the floor.

Simplification of the substructure beams was now undertaken. The original beams had thin webs attached to the caps with rivets. To eliminate the riveting and improve producibility, a one piece extrusion was considered. In order to maintain the strength-weight ratio a 75ST extruded beam was tried. However, the desired web thickness was too thin to permit extruding and us of a thicker web would result in increased weight Further study revealed that the beam could be extruded from ZK60A magnesium and, through the us of lightening holes, could equal the weight of th built-up beams of 75ST Alclad material.[4, 5] In thi particular instance, the magnesium alloy could actually be used to advantage since the web could carr the shear load without buckling, thus eliminating th need for stiffeners. Also, with the increase in flang thickness, higher loads could be imposed withou the threat of failure due to instability.

For development strength tests, it was necessar to establish an exact cross-sectional area of the magnesium beams. This required a special preliminar strength test to determine correct load distribution t the individual beams. For instance, it had been established theoretically that for direct loading in th track region, a beam would absorb fifty per cent o its load and distribute the rest to other beams. However, the test established that only forty-two per cen of a load was imposed on a single beam, no matte whether the load was uniform or concentrated. From the preliminary strength test, the exact distributio of loads was determined and the cross sectional area of the ZK60A beams were calculated. These area were verified by single beam tests. Also, tests wer made to check combined shear and bending on ZK60A magnesium beam with five-inch lightenin holes, *Fig.* 5.

The main cabin floor, as shown in *Fig.* 6, is divided into three parts:

1. Forward floor. This portion of the floor supports the heaviest cargo items and is constructed with longitudinal beams. It extends forward and aft of the center of gravity of the airplane
2. Platform area. This portion of the floor is movable. It can be loaded with cargo on the ground and hoisted into the airplane by the use of an overhead traveling crane located in the fuselage. The platform can then be locked into position and become a permanent part of the floor. It is so designed that its shortest distance is in the transverse direction. The optimum construction determined was ZK60A magnesium transverse floor beams with the 0.460-inch birch-spruce plywood covering
3. Aft floor. This constitutes a small portion of the main cargo floor. It is disposed from the center of gravity of the airplane and, therefore, carries lighter vehicles and cargo than the rest of the

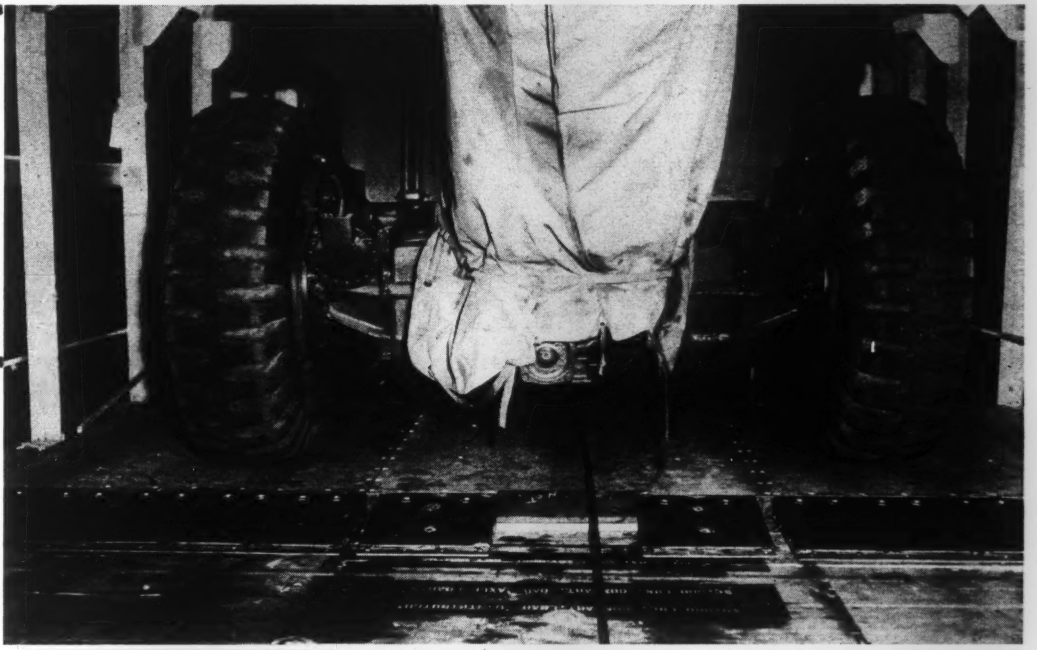


Fig. 7 — Mock-up floor test with 155-mm howitzer in position to be drawn across the floor

floor. ZK60A magnesium transverse beams were used as substructure. Loads were light enough so that the beams could be placed twenty inches apart and co-ordinated with the existing frames thus providing for simple installation. The floor covering of 0.460-inch birch-spruce plywood was still maintained, however, due to highly concentrated loads.

Final Tests: Actual panel strength tests were made before installations were built up and used in production airplanes. Two panels were constructed to simulate the longitudinal and transverse beam construction. The forward main floor test panel, approximately 300 inches long, was supported by a steel jig which simulated the airplane support structure. Longitudinal beams were supported every one-hundred inches by bulkheads. The middle bulkheads were supported by universal fittings and steel tubes which absorbed vertical loads but allowed fore, aft and inboard or outboard movement. The ends of the beams were pin connected at the end bulkheads. A breather joint consisting of a hat section was connected all around the perimeter of the panel and then connected to the jig.

The aft floor test panel was approximately sixty inches long and was supported by a steel jig. Four transverse beams were double pin supported at the point of inflection. The location of the point of inflection was chosen so that the results of the test would be conservative. A breather joint was also employed in this panel.

Wheel loads for both tests were applied by means of hydraulic compression jacks on 70-Shore, hard-rubber pads, equivalent in area to loaded vehicle tires. Electronic deflection scales were used to record deflections. The tests proved the structure was adequate.

Rolling load tests were conducted to demonstrate the strength of the main cargo forward floor section. These rolling loads were applied by a hydraulically operated test jig loaded with lead pigs. The test jig was adjusted for an average speed of three miles per hour and sixty-inch travel with abrupt reversals in direction. Approximately 3000 cycles were recorded without any signs of failure.

A representative forward floor specimen was installed on a C-124A wooden fuselage mock-up. Various vehicles including cranes, tanks, howitzers, etc., were winched and driven over the fuselage floor specimen, *Fig.* 7. Other tests also accomplished were:

1. Wear tests were made by covering the plywood panel with various surface protection materials. Results showed that the birch-faced plywood was comparable to any of the surface materials for wear
2. Mud tests were conducted by applying a considerable amount of mud on the ramp and floors. Even with the excess of mud, vehicles could be driven in and out of the fuselage mock-up
3. Endurance tests showed no signs of cracking or failure in the representative floor panel after driving vehicles over it constantly every day for a period of a month.

To comply with Air Materiel Command requirements, a test was made to demonstrate the ability of the main cargo floor, as installed in the C-124A static test fuselage, to withstand the critical wheel and die-down loads. Excessive deflection and permanent set at limit load as well as failure at ultimate load were checked. Loads were applied by hydraulic jackets. The floor structure withstood all of these load tests and was, therefore, acceptable. In fact, these static tests permitted some ratings to be increased.

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DESIGNING
Cold Impact Forgings

. . . of the strong aluminum alloys offers new opportunities for simplification and cost reduction

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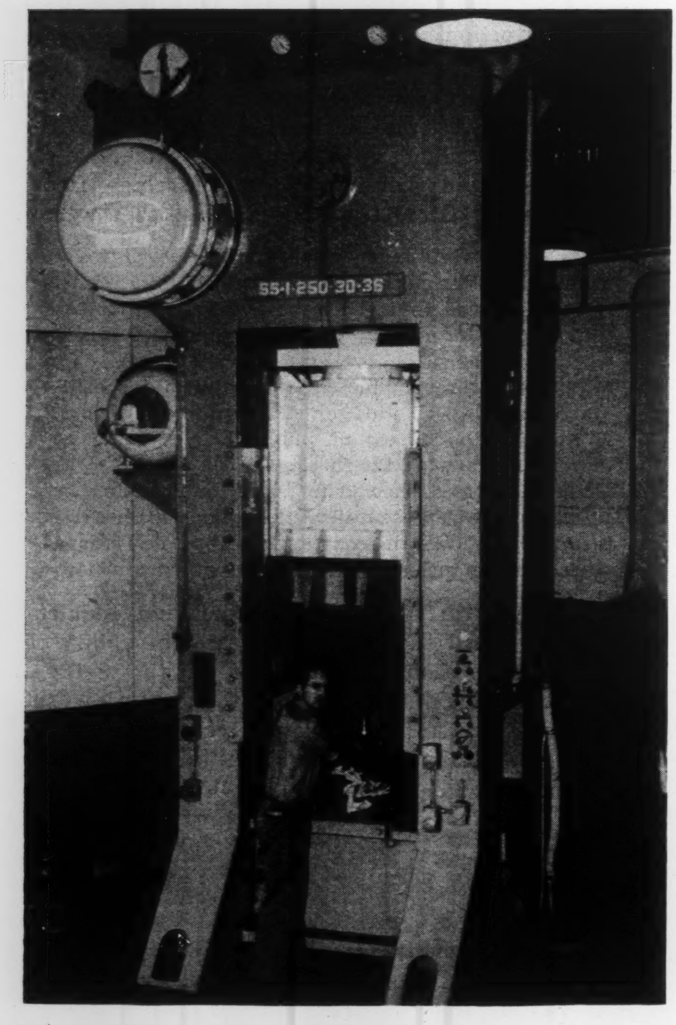
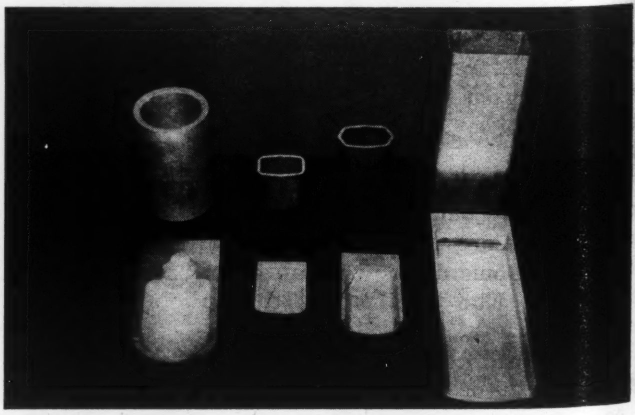


Fig. 1—One of the mechanical presses at Hunter Douglas used for making impact forgings. For certain parts hydraulic presses up to 1000 tons are used

DESIGN engineers are not generally acquainted with the unusual design potentialities currently available in high-strength aluminum impact forgings or impact extrusions. This process utilizes standard forging alloys to produce shapes by cold extrusion or cold forging methods, *Fig.* 1.

Aluminum impact extrusions are, to most engineers, for nonstressed parts such as toothpaste tubes, cans, and boxes and are made from soft alloys—usually 2S. The use of the strong, heat-treated alloys in highly stressed parts is a relatively new development. Over the past year, Hunter Douglas Corp. has been producing Ordnance and aircraft components as cold impact forgings from heat-treatable alloys. It is the purpose of this article to review the design limitations and possibilities inherent in this fabrication

Fig. 2—Cans and cups cold forged from 14S alloy and heat treated to the T6 condition. The three rectangular cans, when cut in half axially, produce two "bathtub" airframe attachment fittings. Walls are 0.130-inch thick. Large can on right is 8¾ inches high



ethod and to describe briefly some components that ave been produced.

When to Design as an Impact Forging: The following factors should be considered in determining hether a particular part may be most economically roduced as an impact forging:

1. When the properties of a hot or cold-worked alloy are required, impact forging should be considered if other criteria discussed are also applicable. Generally speaking, castings will be cheaper if mechanical properties, pressuretightness, soundness, and tolerances are satisfactory for the application
2. Shapes should be hollow. Cylindrical shapes may be round, rectangular, polygonal, or even conical or pyramidal. Symmetry is desired but not mandatory
3. Side walls should normally require zero draft. One of the great advantages of the process is the fact that walls have no draft. At the same time this fact might also be considered to be one of the limitations. In many shapes however, draft on walls is for the convenience of the forging manufacturer and, as in the case of aircraft components, generally the excess metal carried in the draft must be machined away
4. Design should permit elimination of machining operations. Parts can be fabricated to relatively close tolerances. Critical dimensions can often be held as close as ±0.005-inch depending upon location in the part. Since all surfaces are smooth, with walls of zero draft, and since the parts are produced cold, accurate dimensions can be held and machining is usually limited to drilling and tapping and similarly simple operations
5. Production quantities should be required. Cold impact forging of the strong alloys is essentially a high-production precision fabricating process. The need for 25 or 50 units would seldom justify the cost of dies and subsequent heat treatment of the finished part. It would probably be cheaper to machine parts from bar stock. For quantities from 100 and up into the millions, the cold forging of applicable shapes is usually indicated. On certain types of small parts automatic screw machine operations can compete, but normally such is not the case.

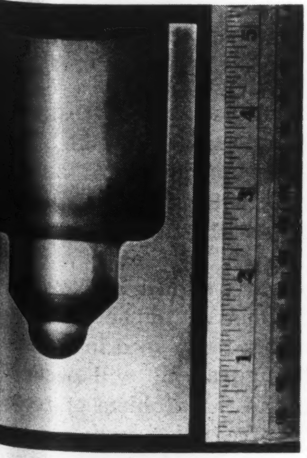


Fig. 3—Shell body for Army Ordnance (axial section) cold forged from 14S. Part is produced from a solid cylinder

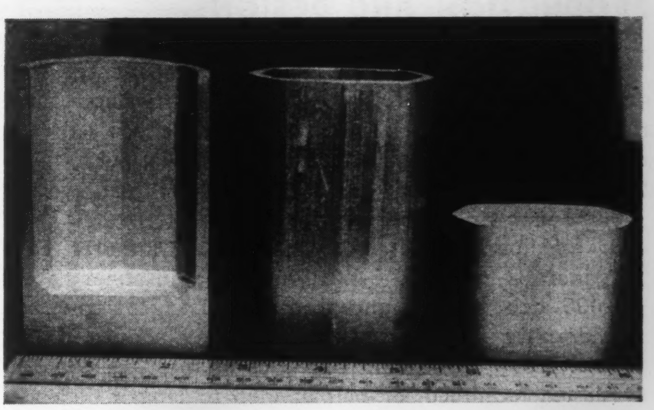


Fig. 4—Close-up view of the octagonal can shown in *Fig.* 2. Axial section is shown on the left and starting forging slugs on the right

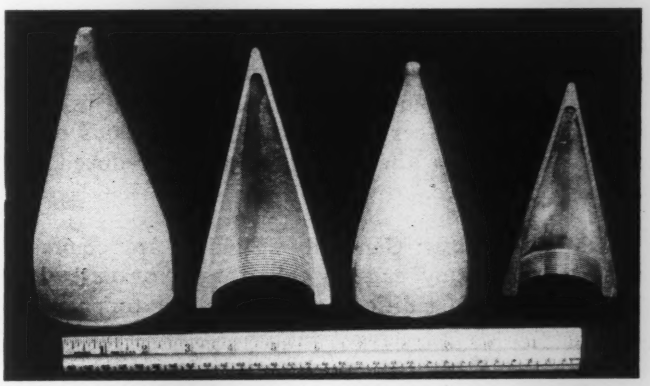
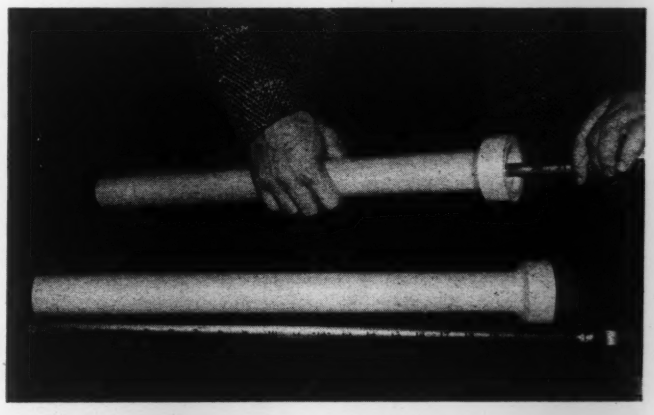


Fig. 5—Sequence of operations in producing small Ordnance forging. Forging blank is punched from alloy plate and cold forged to shape. Finished machined parts sectioned to show interior

Fig. 6—Landing gear plunger for nose wheel of jet plane developed in conjunction with Menasco Mfg. Co. of Burbank, Calif. Produced in one press operation, parts are shown as obtained from the die. Overall length is 21 inches, inside bore 19 inches long, OD 1.750 inches ± 0.010-inch, and ID 1.500 inches, ± 0.010-inch. Alloy used is 14S-T6, and surface roughness is typically 63 microinches, rms. Machining operations are required only on the closed end and flange of open end. Other similar parts up to 25 inches long by 3 inches OD by 0.250-inch wall are in production



Dimensional Tolerances: The cold impact forging or extrusion process is inherently a precision fabricating process. Relatively close tolerances can be maintained on many dimensions. Walls 0.100-inch thick can be readily held to ±0.010-inch, while ±0.020-inch might be required for walls over 0.150-inch and perhaps up to 0.300-inch. Diameter can be generally held to ±0.010-inch and in some cases ±0.005-inch is not unreasonable. Lengths require considerably more latitude and for some shapes might necessitate ±3/16-inch. Can-type shapes are usually machined, trimmed, or belt sanded to length depending upon requirements.

It is difficult to stipulate a crystallized set of tolerances since they can vary for alloy, complexity and geometry of the part. It is at this point that it is desirable for the design engineer to forward a preliminary drawing to the impact forging vendor for comments on configuration and tolerances. It is wise to include a drawing of the finished part to be produced from the cold extrusion since it may be possible to eliminate certain machining operations or to change tolerances that could result in reduced die cost or piece price.

Available Alloys: Generally speaking, any commercial wrought alloy can be cold forged or extruded. There is a distinct difference in the press tonnage required to produce parts in the different aluminum alloys, and shapes that are commercially unfeasible in some alloys may be easily produced in others. Economy dictates that the engineer should not specify any alloy stronger than is required to meet stress needs since a rough rule of thumb states that the stronger the alloy the greater the production difficulties and the higher the cost.

Fig. 7—Another example of a closed-end tube. This is an Ordnance component produced from the Hunter Douglas alloy HD-10. Typical properties on test bars machined from part: 52,000 psi tensile strength, 46,000 psi yield strength, 6% elongation. No solution heat treatment of part. Diameter tolerances ± 0.005-inch

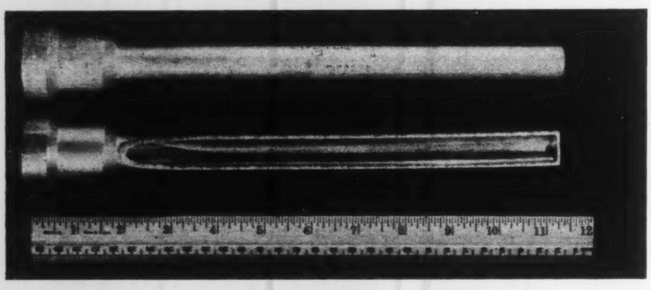


Fig. 8—Shell components. Unusual impact forgings from Hunter Douglas HD-11-T6 alloy. Inside of part is forged to size, eliminating need for internal machining despite close-tolerance requirements

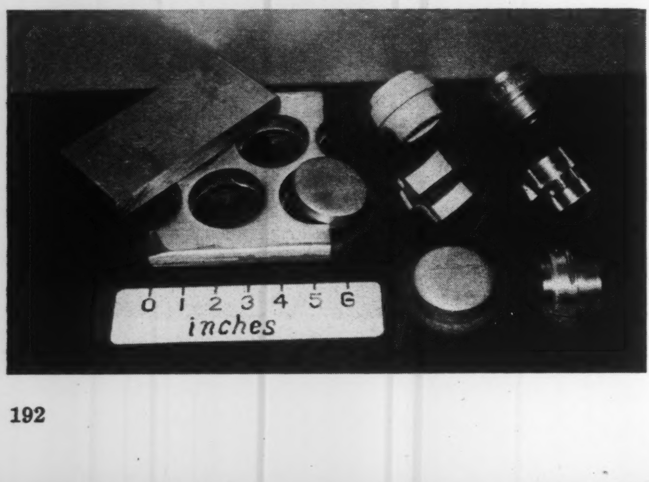


Table 1—Specification Mechanical Properties of Aluminum Impact Forgings

Alloy	Tensile Strength (psi Min)	Yield Strength (psi Min)	Elongation (% Min in 2") Test Coupon	Forgin
61S-T6	38,000	35,000	10	7
A51S-T6	44,000	37,000	14	10
14S-T6	65,000	55,000	10	7
75S-T6	75,000	65,000	10	7
HD-11-T6*	50,000	42,000	10	7
HD-10**	37,000	32,000	5	3

* Hunter Douglas alloy.
**Hunter Douglas alloy not heat treated.

The high-strength heat-treated alloys would be 14S, A51S, 61S, and the Hunter Douglas HD-11. TABLE 1 lists the specification properties that parts must meet. It should be noted that these are identical to commercial hot forging specifications such as Federal Specification QQ-A-367c, "Aluminum Alloy Forgings, Heat Treated."

Alloy 75S has been specified for some airframe impact extrusions but, for the present at least, its use should be limited to the simpler shapes. For applicable parts 75S represents a satisfactory alloy but it appears likely that its cold forging properties will be inferior to 14S on more complicated shapes.

For engineering applications involving moderate loads in service, the nonheat-treated alloys are satisfactory. Compositions such as 52S, 4S, and the Hunter Douglas HD-10 alloy would be quite satisfactory. They are generally more readily cold forged than the heat-treatable alloys, hence piece price is lower. Published mechanical properties are not generally available for these alloys fabricated as impact extrusions, although a set of minimum specification properties for the HD-10 alloy is given in TABLE 1. This specification has been used with notable success for a complex Ordnance shell component. The alloy happily combines ease of fabrication with high mechanical properties in the as-cold extruded condition.

Nonstressed cans, covers, and comparable shapes can be produced from the softest, lowest cost, and most formable materials such as 2S and 3S. This type of part is familiar to design engineers, and no further consideration of these soft alloys is valid in an article concerned primarily with stressed parts.

Applicable Designs: The parts shown in *Figs.* 2 to 8 represent specific applications of impact forgings in the production of components to be used in stressed assemblies. Many other configurations will occur to the ingenious designer who has the problem of reconciling a needed shape with stress requirements and procurement costs. The use of a cold forging or extrusion may well represent an optimum compromise.

Fig. 22—Control charts assist in eliminating human variations but are only as good as the instruments used and the men who make and record the measurements

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QUALITY CONTROL METHODS

Their Use in Design

Part 4–Human Elements In Production

HOW often is it that engineers find it necessary to "design out" the human element! Faced with the inevitable fact that trouble will never entirely be avoided until a "foolproof" design is evolved, the tendency most often is toward complete automaticity.

The problem is familiar; but the right answer is not always so easily resolved. Designing out this element generally does ease the problem, but now and then it is either impractical or impossible to do. Many more times it would be preferable not to have to do it.

Why not try to understand it? Study the human element, learn its traits, and plan to reduce its effects by other means. This can be a real aid to the designer. By influencing the human element certain statistical techniques do help control quality of products, *Fig.* 22.

Shewhart control charts (by variables) let the operator do some good reasoning. He has a real way of not letting his judgment be influenced by only a few of the innumerable variables that are constantly operating in any process. Charts give clear indications upon which he can depend: either no significant changes have taken place or the position of a whole distribution must have been shifted or widened sufficiently so that it would pay to take some corrective action. The indication is the position of the successive average and range points with respect to the control limits. They show whether or not that machine or process needs to be reaimed. Avoided is the

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MANY DESIGNERS feel that, regardless of how production is handled, the general spread of tolerances produced will largely fall into a fairly typical distribution. This is often not the case. To understand why, and further how quality control can provide reliable results desired in design, this part of the series treats the human elements which wield strong influences in production operations

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human failing of being lulled into security just because a part checked now and then meets specification requirements. The chart applies a valid statistical test to the data. It tells whether the net effect of all the variables is stable and like it was previously, or not.

It is good to know when to take action before real trouble begins. But equally important you should know when to leave things alone. There are times when a human wants to be extrasafe. So he is ready to make an adjustment because a reading or two looks as if the process may be wandering off its former position. This "conservative" action by the operator will only put more variation into his output. With the chart instead he can see when to leave things alone.

Making valid corrections, the first characteristic mentioned, markedly cuts the amount of scrap and rework. The second, leaving the process alone, increases the production rate. For operations that are manually controlled at least a ten per cent increase can be obtained.

Why Uncontrolled Production Tolerances are Unpredictable: Most operators, and even supervisors, feel strongly about staying away from the allowable limit reached by maximum stock removal. They reason that material left for possible rework keeps one out of trouble. Too many of these people do not think at the same time of variation as being inevitable or that its amount cannot be neglected. These two traits result in a warped distribution bunched close to one limit and inevitably a portion lies beyond specification.

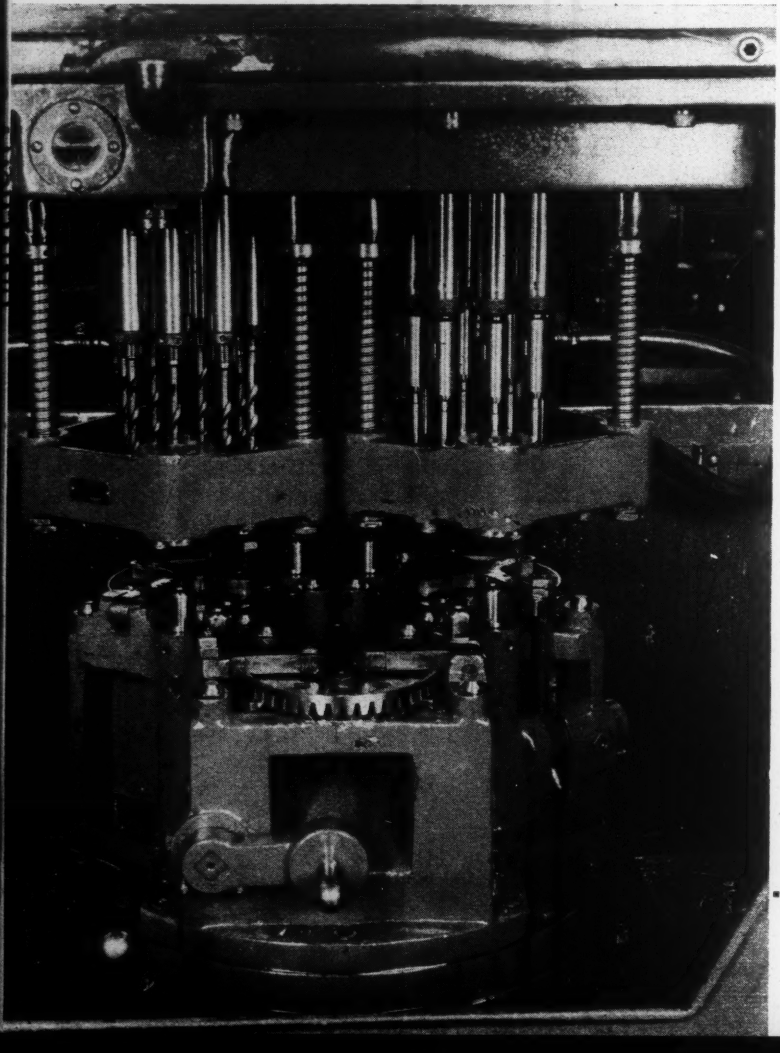


Fig. 23—For a multi-operation sequence on a single piece, only one result picked at random can be employed for a rational subgrouping

This human desire to be safe instead can be made to react favorably with a *p* or fraction-defective chart. The trend of the chart of *Fig.* 16 of Part 3 is not at all unusual. Rather high values of fraction-defective pictorially indicate to the operators in a department their poor performance. The picture results perhaps in an unconscious attempt by everyone to do better. The next points that then show some improvement simply kindle the flame into a real blaze. Time after time, in industry after industry, the use of a simple *p* chart has brought about an almost immediate reduction in fraction-defective. The variation finally levels out and oscillates about an average value that represents about the best that can be done with the department as far as the human element is concerned.

Even an entirely automatic process has a human element. Someone has to decide when the machine is set correctly and to allow it to start its automatic run. Generally the setup man adjusts the process by operating the machine until it produces at least one item of product which he feels is satisfactorily located within the tolerance band. Then he releases the operation. All he really knows is that some of the future production can be expected to fall within limits. A statistical technique can add useful information to his opinion. Reset-Run cards test whether the process is centered correctly, based on the inherent variation that can be expected. It takes out of the realm of guesswork the decision as to just how many initial parts need to be measured for each setting.

Effects of Sample Selection For Production Control: Samples for a control chart should be selected in the order in which they are produced. "Rational or reasonable subgrouping" describes this phase of human endeavor that must be carefully watched to make a control chart valid. The chart should distinguish between chance variations and ones due to assignable causes. Control limits are figured from a steady or stable pattern. When average or range points fall outside this pattern, an extra bit of variation has come into play. Unless care is exercised to keep sample points in the order of production, extra variation, if it exists, can become mixed with the stable. An apparently wider, stable pattern will obtain, and it will not be apparent just *when* the change that needs to be corrected took place.

Also, under the heading of rational subgrouping rests the idea of a control chart being a test of agreement between the sum or average section of the chart and that for ranges. In other words, random samples taken from a single parent distribution will have their averages and ranges fall within certain widths or spreads. A control chart that shows a wide distribution of averages and an unusually narrow spread of ranges, or vice versa, clearly shows that this test is being violated. Something is wrong. The selection of samples or subgroups was incorrect.

Consider a multispindle machine. The same tool does the same operation on different bars of stock in the spindles. If the measurements for each point on your control chart come from a sample of pieces from different spindles, then the range will be a measure of the variation among the spindles while the average points will stand for variation that occurs from one time to another. The two have no connection and cannot be expected to appear as if they were random selections from one distribution except as a very unusual coincidence, *Fig.* 23.

Another example is the grinding of four parallel grooves in one piece. It appeared convenient to the operator to use the four width measurements from each piece as a sample of four readings for each point on the control chart. Here the ranges were small in that one setting of the machine took care of grinding all four grooves. There was very little difference among these widths but the average from one piece to another of these four readings showed a big difference due to a new setting for every piece. Since control chart limits are calculated from the average range, the chart looked as if it were continually out of control in the average section.

The solution in both cases comes from taking the sample in a reasonable manner that does not violate the built-in test of agreement of control chart theory. In the first instance, one spindle at random from each cycle as one measurement, or a separate control chart for each spindle should be used. For the multi-operation sequence on a single piece, only one result picked at random from the grooves in each piece should be used to make up the values for the sample. In this manner the statistical difficulty generally encountered is avoided.

Another factor in how samples are taken depends upon the main purpose of the control chart. Sample selection is important whenever it is undesirable to measure every piece made, as is usually the case for anything close to a moderately high production rate. If the plan primarily is to control the process, sample readings should be taken from a group of successive pieces. Then, if "in control", the process is allowed to continue for a while before again taking a group of adjacent pieces for the next sample.

Perhaps the main objective is to use the control chart for acceptance purposes, controlling the process being a secondary goal. Here the sample should be made from pieces following each other at periodic intervals, rather than directly one after another. The order of production is maintained but the sample readings are spaced. For acceptance purposes, this technique gives a broader picture of the overall level of variation. In the case for process control, care must be taken to make sure that the pieces in one sample would be more like each other so if a change takes place it will stand out rather than possibly be disguised by its being only part of the sample.

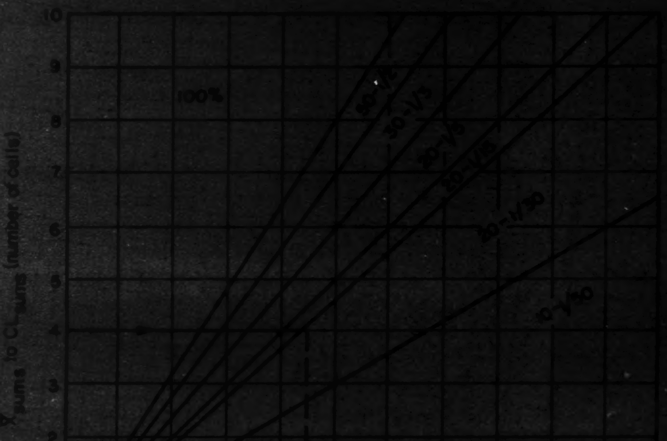
Frequency of Samples: The question of frequency of taking samples is often asked but is seldom answered specifically—the risks connected with the reply are rarely defined. Usually the answer is that it depends upon how well the process, from past experience, seems to be able to hold its stable condition. While this is true, it is again dependent upon the opinion of the person making the decision.

The answer can be reduced to a simple ratio between the inherent spread of the stable variation and the width of the allowable specification. Also tied in is the relative position of the natural variation within the allowable. In other words, if one of the three-sigma limits for the spread of individual pieces is very close to one of the specification limits, then practically all the work must be inspected. But, if a great deal of room exists between the three-sigma limit and the nearest specification limit, then samples at much longer intervals provide an equal risk. In fact, the risk can be computed at whatever level desired.

An example of this sort of thinking is represented in *Fig.* 24. The calculations have resulted in a chart for sum and range control charts using a sample size of four. The risk of this plan is expressed as an average outgoing quality limit (AOQL) of 0.3 per cent. Protection of this type is obtained as follows:

A certain sensitivity is utilized in plotting a sum and range chart; that is, a cell or line interval. Sums and ranges are carried to the nearest 0.001-inch or perhaps to the nearest 0.0002-inch for each line. Step 1, then, in terms of the intervals selected, is to determine the number of lines from the average or mean line to the control limit for sums. Step 2 is to determine how many such intervals there would be from one-fourth of the average of the sums to the nearest specification limit. These two numbers entered into *Fig.* 24 result in an intersection in one of the several

Fig. 24—Chart giving the required frequency of sampling, from 100 per cent checking to one sample out of every 50 possible, for a sum and range chart. Sample size is four and the AOQL or risk is 0.3 per cent



bands shown. The first number shown in the band gives the number of successive subgroups or samples that must be measured and found to be within control limits. The fraction that follows indicates how often to sample in the future. In other words, the fraction 1/3 means that one sample is taken for every possible three samples. When employing a sample size of four, four pieces must be measured, then eight passed by, the next four measured, and so forth. Whenever one of the sum or range points falls out of control some corrective action is necessary along with a return to measuring the number of successive samples in a row indicated by the first number in the band. Too, this means 100 per cent inspection for that period. The correct number of pairs of points inside the sum and range limits will qualify returning to sampling at intervals.

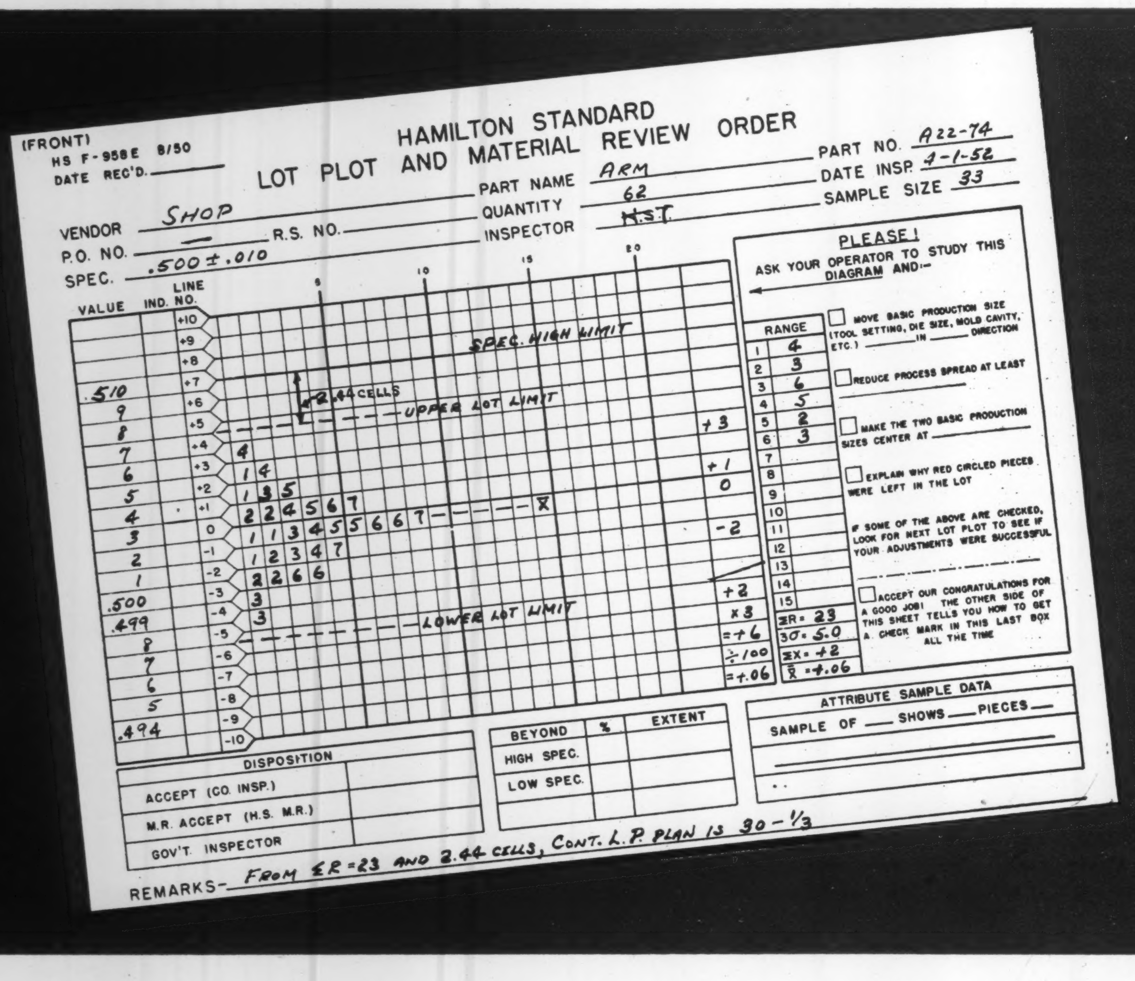
At times material will be released by this periodic sampling and at other times by checking all the work produced. In the long run, the mixture of material released by these two methods will be held in its net defectiveness to a value equal to or less than three out-of-specification pieces per thousand. Charts similar to this one could be worked out of course for other risk levels or sample sizes. The figures would be considerably more liberal if a greater AOQL could be considered acceptable. The method used comes from the Continuous Lot Plot theory that follows.

Confirming Control: A control chart is only as good as the man who made the measurements and recorded them—and as the measuring instruments used. The reasons a control chart does not always guarantee that control was complete can extend from pure dishonesty, through misunderstandings, and end up with oversights, interruptions, or fatigue on the part of the operator. A check is necessary and inspection enters the picture. The inspection results should be independent of the operator who made the readings and of his gages. But it should confirm or deny that the process was being kept in control. This inspection should also be as economical as practicable. The Continuous Lot Plot was developed at Hamilton Standard for this purpose.

It is a sampling plan by variables that has been developed particularly for economical inspection of good material in successive small lots. It will usually pay whenever the quantity in each lot runs anything less than 250 parts. It permits occasional sampling whenever the material is running well within the specification limits, but it clearly and safely announces those lots or portions of lots that will have to be completely detailed because they are suddenly in danger of exceeding the tolerance limits.

Th Continuous Lot Plot starts with the filling out of a Lot Plot form for the first thirty-three pieces made. It may take more than one lot to accumulate this total.

The Lot Plot is another sampling plan by variables that will be described in the next part of this series. It is effective for lots where the order of production is unknown, as would be so when material is received



(FRONT)
HS F-958E 8/50
DATE REC'D. ______

HAMILTON STANDARD
LOT PLOT AND MATERIAL REVIEW ORDER

VENDOR SHOP
P.O. NO. — R.S. NO. ______
SPEC. .500 ± .010
PART NAME ARM
QUANTITY 62
INSPECTOR H.S.T.
PART NO. A22-74
DATE INSP. 4-1-52
SAMPLE SIZE 33

VALUE	IND.	LINE NO.	5 10 15 20	
		+10		
		+9		
		+8	SPEC. HIGH LIMIT	
.510		+7	↕ 2.44 CELLS	
9		+6	UPPER LOT LIMIT	
8		+5	— — — — — —	+3
7		+4	4	
6		+3	1 4	+1
5		+2	1 3 5	0
4		+1	2 2 4 5 6 7 — — — — — — X̄	
3		0	1 1 3 4 5 5 6 6 7	-2
2		-1	1 2 3 4 7	
1		-2	2 2 6 6	
.500		-3	3	+2
.499		-4	3 LOWER LOT LIMIT	x3
8		-5	— — — — — —	=+6
7		-6		÷100
6		-7		=+.06
5		-8		
.494		-9		
		-10		

PLEASE!
ASK YOUR OPERATOR TO STUDY THIS DIAGRAM AND:—

RANGE	
1	4
2	3
3	6
4	5
5	2
6	3
7	
8	
9	
10	
11	
12	
13	
14	
15	
ΣR = 23	
3σ = 5.0	
ΣX = +2	
X̄ = +.06	

☐ MOVE BASIC PRODUCTION SIZE (TOOL SETTING, DIE SIZE, MOLD CAVITY, ETC.) ______ IN ______ DIRECTION

☐ REDUCE PROCESS SPREAD AT LEAST ______

☐ MAKE THE TWO BASIC PRODUCTION SIZES CENTER AT ______

☐ EXPLAIN WHY RED CIRCLED PIECES WERE LEFT IN THE LOT

IF SOME OF THE ABOVE ARE CHECKED, LOOK FOR NEXT LOT PLOT TO SEE IF YOUR ADJUSTMENTS WERE SUCCESSFUL

☐ ACCEPT OUR CONGRATULATIONS FOR A GOOD JOB! THE OTHER SIDE OF THIS SHEET TELLS YOU HOW TO GET A CHECK MARK IN THIS LAST BOX ALL THE TIME

DISPOSITION	
ACCEPT (CO. INSP.)	
M.R. ACCEPT (H.S. M.R.)	
GOV'T. INSPECTOR	

BEYOND	%	EXTENT
HIGH SPEC.		
LOW SPEC.		

ATTRIBUTE SAMPLE DATA
SAMPLE OF ____ SHOWS ____ PIECES ____

REMARKS— FROM ΣR = 23 AND 2.44 CELLS, CONT. L.P. PLAN IS 30 − 1/3

Fig. 25—Examp
initial Lot Plot
gives lot limit
tions. The numb
the distribution
to the order of
urements

from vendors. It becomes the most convenient plan to use whenever the material may be beyond specification, but usable, or arrives in rather large lot sizes. The sample size used for these standard applications of the Lot Plot is a fixed 50 pieces selected at random from the lot.

In this application a slightly modified Lot Plot serves simply as a first step to be able to employ the Continuous Lot Plot. From the frequency distribution, *Fig.* 2 of Part 1, shown on this introductory Lot Plot, *Fig.* 25, the upper and lower lot limits are calculated as being equidistant from the average, the line marked $\overline{X}$. These limits represent size values on the left-hand vertical scale that can be expected to occur only at the rate of about one to two parts per thousand pieces. For all practical purposes these can be considered as the natural tolerance limits for the process.

Table 1—Conversion of Sums of Ranges to Three-Sigma Limits

Sums	Cells	Sums	Cells	Sums	Cells
14	3.0	23	5.0	32	6.9
15	3.2	24	5.2	33	7.1
16	3.4	25	5.4	34	7.3
17	3.7	26	5.6	35	7.5
18	3.9	27	5.8	36	7.8
19	4.1	28	6.0	37	8.0
20	4.3	29	6.3	38	8.2
21	4.5	30	6.5	39	8.4
22	4.7	31	6.7	40	8.6

The $\overline{X}$ line and the lot limits are found from this procedure:

1. Cut out the column of printed plus and minus line numbers from a blank Lot Plot form
2. Place this column vertically on the right-hand end of the frequency distribution on the Lot Plot so that the printed zero cell falls directly on the horizontal row of measurements that contains the largest number of entries
3. Move this cut-out column to the left and note whether the +1 or −1 cell uncovers the most readings. In the case of *Fig.* 25 the +1 cell has one more value in it than the −1 cell
4. Multiply this excess of one by the cell value, plus one, to give a product of plus one. Write it down in the right-hand column above the written zero that is also there
5. Move the column further to the left, noticing the +2 and −2 cells. Here the −2 cell has an excess of one reading and this one times minus two equals minus two, the entry at the right
6. This process is continued. One extra value is found in the +3 cell as compared to the −3, but the +4 and −4 cells just balance out in this example
7. The results in the right-hand column are added, paying attention to the signs, the total in this case being plus two
8. Multiply this answer by three, and divide by 100 to give a figure for the average of plus 0.06. Taking 3/100 of the net unbalance of the distribution is equivalent to taking 1/33. This means the $\overline{X}$ line is located at 0.06 of a cell above the midpoint of the cell used as a starting point for zero
9. The first five pieces inspected were entered as five "1's" in the Lot Plot. The next five readings were marked as "2's", etc., ending up with three "7's". To see how the results are plotted, notice that the listed values in the extreme left-hand column are labeled and positioned as the values of the printed lines. Any piece must give a measurement that falls between a pair of lines on the gage, so the first five pieces received from the shop are entered between the corresponding printed lines on the form
10. This numbering makes it easy to fill in the range values, further to the right on the form. Counting from the lowest "1" to the highest "1", starting with zero, four is the range of the first five measurements. From the lowest "2" to the highest "2" we get zero, one, two, three, giving a range of three, and so forth. The six ranges are counted in this manner. The three "7" values are not counted in this way as they were only entered to facilitate the computation of the average
11. Total the six ranges, which in this case gives 23. TABLE 1 converts this summation of the range values to three standard deviations in terms of cells. The result of five cells is then counted up and down away from the average line to fix the positions of the upper lot limit and the lower lot limit
12. Pick out the lot limit that is closest to a specification limit and determine the number of cells from it to that specification limit. Enter with this value in the left-hand scale of *Fig.* 26. Read over

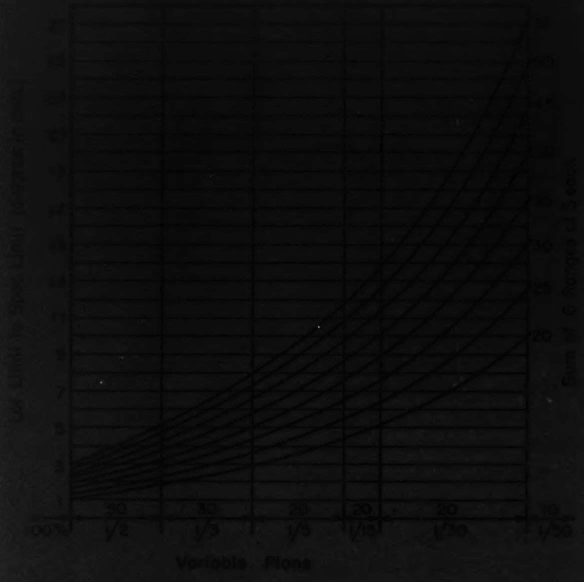


Fig. 26—Data from initial Lot Plot permit picking a plan for Continuous Lot Plot. Each plan has an AOQL of 0.3 per cent

to the right on this chart to the curved line that corresponds to the sum of the ranges from the Lot Plot. In the example of *Fig.* 25, using a value of 2.44 cells, read over to a curve that would correspond to a range sum of 23. This gives a Continuous Lot Plot plan that requires 30 successive pieces to be found within lot limits to permit sampling at the rate of one out of every three pieces

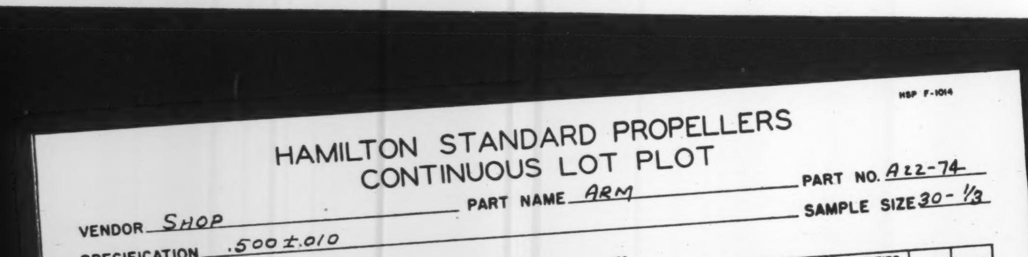
13. Enter the results of the future sampling of one out of every three pieces on the Continuous Lot Plot form shown in *Fig.* 27. The "1's" here correspond to the pieces sampled from the first lot, the "2's" from the second lot, and so forth.

It is only when one of these numbers is found to be outside of the lot limits that the next thirty pieces have to be checked and found successively inside the lot limits before sampling can be resumed. If, say 28 pieces are found within lot limits and the 29th is outside, the process must be started again from one to try to find the next thirty within these limits. The result of following this plan, in the long run, will keep the material involved to an average outgoing quality limit of 0.3 per cent, or no worse than three defective pieces (beyond specifications) per thousand. This plan effectively keeps tabs on the shop. It tells when the processes are being left alone. Also it warns when the human element is disturbing things to such an extent that a different inspection rate is required to keep the possibility low of defective material being passed.

What Really Controls Production Results: It might be well worthwhile to consider how the actual results of detailed production are determined. Certainly shop gaging physically controls them most directly. The operator reads his gage, whether he uses a chart or not, and tries to get certain results by adjusting his machine accordingly. Next in importance comes the shop operator. He has human traits—how he uses his gaging, runs his process, handles raw stock, etc.

Three other factors that also control the actual dimensional averages and variations therefrom are the fabricating equipment, inspection gages, and the inspectors. The drawings only serve as the first approximation of what three of the five factors—shop gages, manufacturing equipment, and inspection gages—should be. Quite often the drawings are not used at all once the "tooling" is picked. Vendors realize that parts can be made better to the purchaser's inspection gages rather than to his drawings and often with less question.

The statistical techniques serve as the only economical control of the condition of equipment and of the part the operator and inspector as humans play in establishing the actual sizes obtained. They bid well to bring closer the agreement between results and the drawing requirements. This is the key reason why designers will find their understanding and use invaluable in employing realistic tolerances so drawings will gain proper respect. The next part in this series will consider "The Human Element in Inspection", basic material on realistic tolerances following.



HSP F-1014

HAMILTON STANDARD PROPELLERS
CONTINUOUS LOT PLOT

VENDOR SHOP
PART NAME ARM
PART NO. A22-74
SAMPLE SIZE 30-1/3
SPECIFICATION .500±.010

5
10
15
20
SPEC HIGH LIMIT
UPPER L.L.
LOWER L.L.

.510							
9							
8							
7	3						
6	1	4					
5	1	1	2	3			
4	2	2	2	2	4	4	4
3	1	2	2	3	4		
2	1	1	2	2			
1	1						
.500	2						
.499							
8							
7							
6							

LOT NO.	R.S. NO.	QUANTITIES	A	B	DATE	INSP.
1		20			4/3	H.S.T.
2		29			4/5	H.S.T.
3		9			4/10	W.R.W.
4		15			4/12	H.S.T.
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						

REMARKS:

Fig. 27 — Continuous Lot Plot shows whether there has been a change in the process which necessitates a differing inspection rate

DESIGN ABSTRACTS

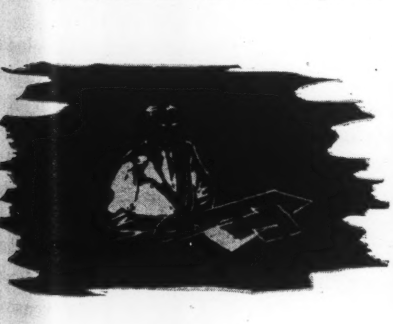
Your Engineering Attributes

How do they meet the qualifications of industry for professional accomplishment and personal success? Here, in order of importance, are the necessary qualities for engineering achievement

By J. Kenneth Salisbury
Division Engineer
Thermal Power Systems Div.
General Engineering Laboratory
General Electric Co.
Schenectady, N. Y.

EVERY normal industry in this nation that is led by intelligent forward-looking executives wants to improve. Industry does not assume the character of its financial statement or of its physical facilities; rather, it assumes the character of its people—people who are identified by their personal characteristics. In the long run, therefore, industry can improve itself only by adding employees with desirable characteristics.

What are the desirable characteristics that we'd like to find in engineers? To me, there are 15 vital qualities. The first five are absolutely essential for an engineer to attain the acme of professional accomplishment and standing. We may class these qualities, therefore, as *indispensable*. The second group we may class as *essential* and the third can be called *important*, although I doubt that this word is strong enough.



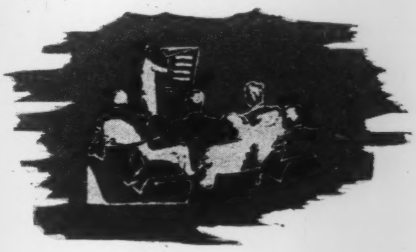
Any single engineer who possesses all of these good qualities is a superman. All of us, on the other hand, have most of these qualities to some degree.

Indispensable Qualities: Although developed formally in a college engineering course, *technical ability* usually is also the product of one's environment, hobbies and natural inclinations. It can be divided into two major subdivisions: creativeness and ingenuity, and analytical ability. Only rarely does an engineer of high technical ability possess both to an outstanding degree.

One normally tends to catalog engineers either as analyzers or as synthesizers—the analyzers are the appraisers and evaluators; the synthesizers are those who are creative and ingenious in devising new ways of doing things. This sharp division is somewhat fallacious, however, because there is considerable overlapping.

Aggressiveness must accompany technical ability. One must, for example, have the energy, the vigor of intellect, and the spark to exercise his technical ability, or it avails him nothing. He must have the will to win.

Every engineer with experience in industry has encountered the person of superb technical competence, capable of handling with ease fourth-order differential equations, or solving the most difficult problem in thermodynamics, but incapable of initiating the accomplishment of any useful objective.



These people tend to sit in a corner and wait for their problems to come to them. They perform beautifully when given a specific assignment and a date on which it must be completed. They do not initiate new work in which they can make advantageous use of their special talent.

On the other hand, all of us have known pepole with mediocre technical ability who are continually thinking about the job, and who perform assigned work expeditiously to the full extent of their somewhat limited abilities.

These are the aggressive ones—the ones who are outstanding performers when used within the limits of their technical abilities. They move swiftly and surely. Things happen when they are around. Often such people have a high degree of intelligence and horse sense but are not naturally gifted in technical matters. They recognize their limitations, and it is the problem of management to make available for their assistance others who excel them in purely technical matters. Thus is formed a team that has more capacity than the sum of the capacities of the individuals. Leaders in industry frequently have aggressiveness as their outstanding characteristic. It is the high-octane quality that drives them to top accomplishment.

Understanding of human relations is vital in the business world. The aggressive engineer who does not comprehend through his understanding of human relations the effect of the aggressiveness on his associates is likely to incur their serious displeasure, and as a result fail to obtain their co-operation.

Skill in human relations implies an innate personal kindness — a tolerance toward the shortcomings of others. Above all, it requires fairness in dealing with people and a generosity of spirit. In a supervisor it requires a comprehension of the things that motivate the individual, a recognition of his merits, and a knowledge of his weaknesses.

Only rarely in industry does an engineer make a complete failure of his career through lack of technical ability alone. He may be consigned forevermore to the ranks of mediocrity, and his professional attainment may be at a very low level. Nevertheless, he usually is permitted to earn a satisfactory living, and to fill a place in industry however lowly it may be, provided he gets along with his fellow workers.

On the other hand, there are numerous failures in industry that result from lack of understanding of human relations. These are the people who within the first minute of a conversation arouse a feeling of antagonism. These are the ones who disregard the rights and sensibilities of others, who rise by stepping on the shoulders of their associates. Such gains are transient. They are effective for a brief moment, but they build up a permanent deficit in the human-relations account. They presage the future lack of co-operation by others that limits the engineer's accomplishments.

It has long been my opinion that the key to all understanding of human relations lies in a single word—sincerity. The man who is really and truly sincere never has difficulty in getting along with his associates. His objectives, his motives, and his activities are known and understood by everyone.

It is the cagey ones, the tricky ones, and ones with ulterior motives who have difficulty. It is the ones who "speak not as they think" that have trouble. This does not, obviously, prohibit the use of tact in one's dealings with his fellow engineers, but it does completely eliminate untruths and half-truths, and concealment of pertinent facts.

Responsibility is the fourth indispensable characteristic. The successful engineer must have high personal and company standards of responsiblity. He must be willing to accept responsibility even though it is not specifically thrust upon him. He must assume that he is personally responsible for the success of the endeavors in which he is engaged. He must accept responsibility for failures like a man, and he may also, though modestly, take unto himself responsibility for successses.

Moreover, he must realize that he and his company are one and the same. He must relieve his boss of concern for the project assigned to him. In return his boss is obligated to support him in all reasonable requests for assistance. He must make decisions, but at the same time have the good judgment to consult his superiors on any questionable decision that he may be called upon to make, because such sagacity is actually the essence of responsibility.

Personal integrity, the fifth indispensable quality, may also be called highmindedness. It is the all-consuming insistence of the engineer that he do what is right at all times. It is character. Those who lack it—who are too smooth, who are too clever in the reprehensible sense—are limited forever.

Personal integrity implies an intrinsic honesty, an intellectual fairness in all things, and good judgment. It is sincerity. It is the quality that speeds transaction of the day's business. It is identified by promises that are kept, though made in a word or two, even whe forgetfulness might provide a plausible excuse. It eliminates the need for written instructions, and for confirming memoranda.

Essential Qualities: First of the qualities essential to a brilliant career are *leadership and organizing ability*. They can be developed by all engineers, even in the earlie years. Leadership is the produc of many things, including the fiv indispensable characteristics.

Invariably, leadership include the important ability to inspir one's associates. Inspiration frequently is the result of one's conduct of his own personal job. A emulation of the boss's approach t problems is natural and norma The members of his organizatio nearly always reflect his standard and aspirations. For this reaso then, if for no other you may demand that your boss be a superior person. Indeed, he must be, if you wish to improve yourself. Subconsciously you will acquire at least some of his personal characteristics.

Administrative ability has been typified by one accomplished engineer of my acquaintance in one word—persuasiveness. To convince others to do things, one must clearly explain the overall objectives, the logic behind the method of procedure, and the worthwhileness of the objective. Only when subordinates can carry on without assistance from the leader has he accomplished the basic purpose of organization: delegation of responsibility.

Responsiveness is my own private term for a combination of characteristics. It is a willingness to see the boss's point of view, and an intense desire to carry out any reasonable objectives laid down by him. It is co-operativeness, promptness, reliability, dependability.

Engineers in industry are expected to have initiative and originality, and to require only occasional supervision. A large part of what they actually do is self-inspired, and intended to be. Occasionally, however, a specific instruction is given by a superior, either on a small task, or on one of considerable duration. Such instructions should take priority over self-inspired work, which must be deferred until the specific objective is accomplished. Responsiveness is that characteristic which causes the engineer to set to with a will, finishing the work completely, and in the shortest possible time.

Adaptability increases the usefulness of any engineer. He must be willing to undertake any assigned job, and to devote his every effort to mastering it, regardless of whether it is his personal choice.

Adaptability is a willingness to work under handicaps. Regardless of where an engineer works, there are situations that are not palatable to him, that make it more difficult for him to carry out his assigned responsibilities, and that slow him down. One must be adaptable, and willing to accept these things, because they exist universally, and appear in many forms.

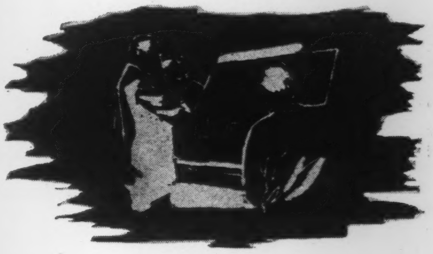
Prospective is the quality that permits an engineer to assign correct relative importance to all things within his scope. It is the quality that permits him to make approximations when they are justified; it is the quality that impels him to work on things which are important to his company, or which may be important in the future. The man who has perspective invariably does first things first, relegating nonessential items to a later time in his work schedule.

Perspective is the quality that enables an engineer to understand his position in an organization and in a company. Also, it enables him to assume authority when he should, to delegate it when he can, and to consult his superiors when it is advisable. An engineer without perspective is a ship without a rudder. Although experience is bound to improve perspective, perspective is basically a native talent. Engineers with perspective are able to select the critical problems, the ones that are really pressing, because they clearly see the overall size and shape of the main issue.

Introversion and extroversion are very personal qualities which, when they appear in combination, are of tremendous value to an engineer. The introvert is the thinker—the man with internal self-confidence that can result in useful, progressive, forward movement. On the other hand, for maximum achievement the engineer must combine a modicum of extroversion with his normal introversion. His introversion enables him to seclude himself, and after objective study, to arrive at the right answer. However, his extroversion then enables him to sell it to his associates and to his superiors. No idea, regardless of its worth, is of value until it is implemented.

Important Characteristics: In both company and business, *ethics* are the responsibility of the engineer. It is easy for an engineer to live in his environment if his personal code of ethics is consistent with that of his company. It is hazardous and unpleasant for him if it is not.

Cost consciousness is an important attribute — consciousness not only of dollars but also of manpower, of materials, of effort. Every engineer eventually controls to some degree the expenditure of these ingredients of his company's products. He must exercise this control wisely, and with perspective.



Confidence is tremendously desirable. The engineer must have confidence in himself, and in his company. He can then give to those with whom he works the strength of spirit and the morale that are essential to forward progress. Confidence does not mean cockiness. It is rather a quiet conviction of competence and adequacy. It is born of experience—past successes.

Efficiency causes one to economize on his time, to plan his work well, and to exercise extreme self-discipline. To a very considerable extent, it is the young engineer's integrated effort over his first 10 years in industry that measures his accomplishment at the end of that period. His work is not only in the interest of his company but even more in the interest of self-development. It is my firm belief that the individual profits far more by his own intensive effort than

(*Continued on Page* 277)

NEW PARTS

AND MATERIALS

. . . presented in quick-reference data sheet form for the convenience of the reader. For additional information on these new developments, see Page 217

RIGID PLASTIC PIPE

1

. . . has greater tensile and flexural strength

Carlon Products Corp., 10225 *Meech Ave., Cleveland* 5, *O.*

Increased resistance to burst pressure (over 1000 psi in 1 in. diam size) is claimed.

Designation: Type L.

Size: ½ to 2 in. pipe size; 10 and 20 ft random lengths.

Service: For pressure or suction lines; ultimate tensile strength, 6000 psi; effective tensile for piping applications, 3600 psi at room temperature; flexural modulus, 250,000 psi; impact strength (Izod), 4.3 ft-lb per in. notch; burst pressure varies with pipe diam; resists chemicals and sunlight; will not rot, rust or corrode electrolytically; easily handled; new fitting available to connect pipe without threading or cementing.

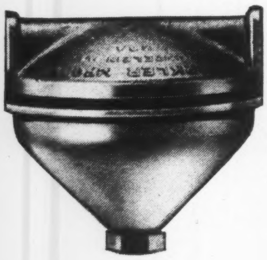
For more data circle MD 1, Page 217

GASOLINE FILTER

2

. . . installed on fuel line without support

Sparkler Mfg. Co., Mundelein, Ill.



Light in weight, this filter can be installed at any point in the fuel line.

Designation: MB-3.

Size: Weighs 2½ oz.

Service: Filtering dust, fine rust and microscopic particles from gasoline; flow rate is relatively high considering degree of filtration; gasoline supply tubing holds filter without vibration.

Design: Nonwoven rayon cloth filtering element, with tightly locked fibers; installed at any point in fuel line without supports or mounting brackets.

For more data circle MD 2, Page 217

HERMETICALLY SEALED RELAY

3

. . . miniaturized for airborne applications

Advance Electric and Relay Co., 2435 *N. Naomi St., Burbank, Calif.*

ADVANCE
RELAY
PART NO C8720-1

Designed especially for electronic equipment, this relay can be used wherever miniaturization is a factor.

Designation: C-8720-1.

Size: $1\frac{13}{32}$ in. high, $\frac{15}{16}$-in. wide, ¾-in. deep; weight, 1.3 oz.

Service: Hermetically sealed for altitudes to 85,000 ft; meets specification AN-E-19; withstands 10*g* vibration with minimum power of 500 milliwatt; coil resistances available to 16,000 ohm; silver contacts rated 1½ amp, palladium rated 3 amp.

Design: Single-pole double-throw or double-pole double-throw; pure silver or palladium contacts; available with glass-silicone insulation.

For more data circle MD 3, Page 217

HEAT RESISTANT PAINT

4

. . . withstands temperatures to 1700 F

Speco Inc., 7308 *Associate Ave., Cleveland, O.*

This paint air dries in 30 min to form a solid copper coating which expands and contracts with temperature changes.

Designation: Heat Rem XG-170 Gold.

Size: 1 and 5 gal pails, 55 gal drums.

Service: Protecting iron and steel surfaces exposed to temperatures as high as 1700 F from rusting; resists corrosion from mild acids, alkalies and industrial fumes; may be used for brushing, spraying or dipping; air dries in 30 min or may be baked.

Properties: Copper flake in silicone resin base which appears to hold copper in place until it is firmly bonded to the iron or steel.

Applications: High pressure boilers; ovens; engine manifolds, exhaust lines, and heads; heat lines.

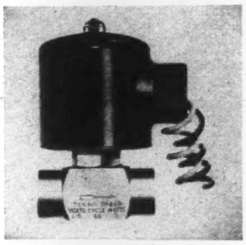
For more data circle MD 4, Page 217

NEW PARTS

SOLENOID VALVE 5

. . . has wide range of applications

A-P Controls Corp., 2450 *N.* 32*nd St., Milwaukee* 45, *Wis.*



Two body styles with two types of needle and seat construction make this valve useful for many industrial applications.

Designation: Model 67.

Size: ⅜-in. pipe or ½-in. OD tube.

Service: For air, oil, water, gasoline, alcohol, detergents, refrigerants, butane, propane or other noncorrosive liquids and gases; capacity, 78 gph of water or 1 ton Freon 12 in refrigerant applications; working pressure to 300 psi; operating differential—130 psi for liquids, 200 psi for air and other gases, 250 psi for refrigerants.

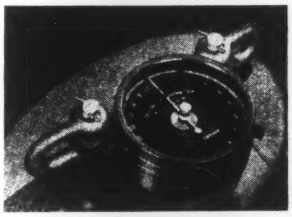
Design: Synthetic resilient disk-type needle seats against a stainless steel orifice to provide "bubble-tight" operation; furnished with stainless-steel needle and valve seat for other applications to prevent "ovaling" and wire drawing of the seat, even after long periods of continuous operation; overpowered coil provides ample lift at 85% rated voltage, and is frost and moisture resistant; conduit connection in cover can be rotated to any desired position by loosening the cover nut.

For more data circle MD 5, Page 217

TENSION DYNAMOMETER 6

. . . prevents accidental overload

W. C. Dillon & Co. Inc., 1421 *S. Circle Ave., Forest Park, Ill.*



Warning signals, relays, motors or switches can be operated when load reaches predetermined point.

Designation: EL.

Size: 5 or 10 in. diam dial, optional.

Service: Preventing accidental overload or in weighing operations; individually calibrated for accuracy; load ratings, zero to 500, 1000, 2500, 3500, 5000, 7500, 10,000, 15,000, 20,000, 30,000, 40,000, 50,000, or 100,000 lb; electrical contacts for 6, 8, 10, 12 or 24 v dc; rustproofed and moistureproof.

Design: As tension load is imposed, a calibrated beam is deflected, moving white pointer carrying one contact around dial; when white pointer meets blue hand, which has previously been set to desired load value, electrical circuit is closed; red max hand; shatterproof safety-glass crystal; furnished with shackles and attachment pins.

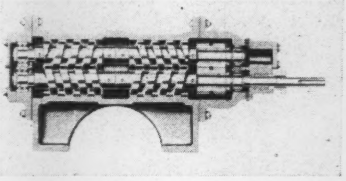
Application: Cranes; hoists; automatic batching machines; load test apparatus.

For more data circle MD 6, Page 217

SCREW PUMP 7

. . . for lubricating fluids or semifluids

Sier-Bath Gear and Pump Co. Inc., 9252 *Hudson Blvd., N. Bergen, N. J.*



This pump is a companion to the recently announced bracket type for nonlubricating fluids and semifluids.

Size:

Model	Ports Suction (in.)	Ports Discharge (in.)	Model	Ports Suction (in.)	Ports Discharge (in.)
A	2	1¼	F	5	4
B	2½	1½	G	5	4
C	3	2	H	6	5
D	3	2½	I	8	6
E	4	3			

Service: Capacities from 1 to 700 gpm; discharge pressures are 1000 psi for viscous liquids and 500 psi for light oils; long rotor life and continued volumetric efficiency, since there is no metallic contact between rotors; direct connection up to 1800 rpm.

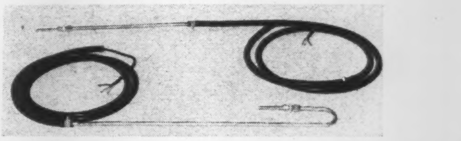
Design: Internal gear and bearing type screw pump; heavy duty roller bearings just inboard of timing gears where radial load is heaviest; locknuts behind the timing gears permit easier repairing; double-row angular-contact ball bearings position rotors axially for less wear on bearings and timing gears.

For more data circle MD 7, Page 217

WATER LEVEL CONTROL 8

. . . indicates and controls liquid level

General Electric Co., Control Dept., Schenectady 5. *N. Y.*



This control is claimed to be exceptionally useful for unattended locations.

Designation: Thermasul.

Size: Enclosure, 14$\frac{29}{32}$ to 16⅞ in. high, 12⅛ to 15$\frac{1}{16}$ in. wide, 6¼ to 8¾ in. deep.

Service: Indicating and controlling water level; noncorrodible, self-cleaning detectors; can control pump motors and circuits for alarm, supervisory and control equipment; relay contact rating, 1 amp at 115 v ac, 0.05-amp at 48 v dc, 0.02-amp at 125 v dc; actuates in approx ½-min in water at 20 C.

Design: Detector consists of resistance heater wound around temperature-sensitive sintered-sulphide compound inside hermetically sealed stainless tube; in air, resistance of element is low because heater maintains detector temperature at approx 280 C above ambient; when immersed, heat is conducted away and resistance increases, operating a single-pole double-throw relay; detectors are mounted with simple pipe supports; straight and hooked probes from 1 to 10 ft long available.

For more data circle MD 8, Page 217

NEW PARTS AND MATERIALS

VOLATILE RUST INHIBITOR 9

. . . protects metal without coating

Shell Oil Co., 50 *W.* 50*th St., New York* 20, *N. Y.*

Vapor from this slightly volatile nitrite salt condenses on metal surfaces, or dissolves in condensing moisture, to passivate the surfaces and prevent corrosion.

Designation: VPI.

Form: Crystalline powder.

Service: Protecting steel products during storage and shipping and between machining operations; barrier must be provided to prevent escape of vapor; metal objects should be covered or packaged, but need not be airtight or moistureproof; arrests corrosion at any stage.

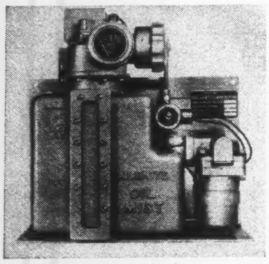
Properties: Crystals give off vapor, which protects surfaces; melts at 310 F without decomposing; practically odorless; 1 gm saturates about 20,000 cu ft at room temperature; moderately soluble in water; very soluble in methyl alcohol; slightly soluble in low molecular weight polar solvents; practically insoluble in hydrocarbons; no undesirable effects on nonmetals, nonferrous metals or bimetallic couples.

For more data circle MD 9, Page 217

OIL-MIST LUBRICATORS 10

. . . signal when oil level becomes too low

Stewart-Warner Corp., 1826 *Diversey Pkwy., Chicago* 14, *Ill.*



Automatic warning switches operate a horn and red light, or shut off the machine.

Designation and Size: 4958 and 4959, 1 gal capacity; 4960 and 4961, 12 oz capacity.

Service: Feeding oil mist at up to ½-oz of oil per hr to max of 60 bearings; require 1.5 cfm air at 20 psi when operated at max output; switch operates when oil level falls below 23 oz on 4958 and 4959, below 2 oz on 4960 and 4961; lubricator operates only when machine is running; 1 gal unit generally provides 1 month supply, 12 oz unit provides 1 week; 4958 and 4960 can operate auxiliary warning signal which shows red light and operates howler unit when level is too low; for 115 v 60-cycle ac; warning switch must operate auxiliary load relay.

Design: Oil-mist unit with float-actuated oil-level indicator switch, air regulator with gage, loader fitting, solenoid air-control valve, water separator, mounting bracket, and locking cover; 4958 and 4960 have normally open warning switch, 4959 and 4960 have normally closed.

For more data circle MD 10, Page 217

RUBBER HOSE 11

. . . has unusually high acid resistance

Hewitt-Robins Inc., 668 *Glenbrook Rd., Stamford, Conn.*

This hose is claimed to resist concentrated organic and inorganic acids, as well as alkalies and chlorine and saturated-chlorine water.

Size: Acid conducting ¾, 1, 1¼, 1½, 2, 2½ and 3 in. ID; acid pinch-valve, 1, 1¼, 1½, 2, 2½, 3, 3½, 4, 4½, 5. 6, 6⅝, 8, 10 and 12 in. ID; acid suction, 1½, 2, 2½, 3 and 4 in. ID.

Service: Conveying acids with following concentrations—100% for acetic, hydrochloric and hydrofluoric, 98% for sulphuric, 86% for fuming nitric in intermittent service, and 75% for nitric; resists alkalies, chlorine and saturated-chlorine water.

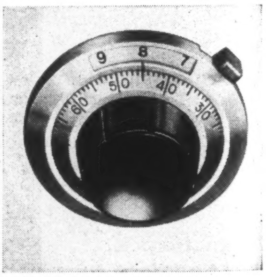
Design: Wrapped duck type; conducting hose consists of 4 or 5 plies of high-tensile duck with plies insulated with rubber layers; pinch valve hose has wall reinforcement divided into 2 wrapped duck units separated by layer of flexible rubber; suction hose is wire-reinforced, smooth-bore type with wire between plies.

For more data circle MD 11, Page 217

MULTIPLE-TURN DIAL 12

. . . reads to 3 or 4 significant figures

Helipot Corp., S. Pasadena 20, *Calif.*



Up to 15 turns of the shaft can be read from the double dial.

Designation: RA Duodial.

Size: For ¼-in. shaft (adapter available for ⅛-in. shaft); 1$\frac{13}{16}$ in. diam, 1 in. extension from panel front; 1 in. diam knob.

Service: Accurate setting and reading of 10 turns of shaft (up to 15 turns available, special); primary scale divides single turn into 100 divisions; secondary scale shows number of turns; no backlash error since worm gears not employed; locking mechanism prevents shifting by vibration; hand capacitance eliminated.

Design: Primary dial, coupled directly to shaft, engages a jump gear when shaft is about to complete one revolution to turn secondary dial to next number; lock is cam-actuated brake shoe which acts radially against an inner drum; black nylon knob; satin-chrome dial surfaces with recessed black figures; included with unit are panel-mounting plate, reversible nut for use with thick or thin panels, and Allen wrench for tightening both knob set-screws; miniature RAJ 10-turn unit for ⅛-in. shaft also available.

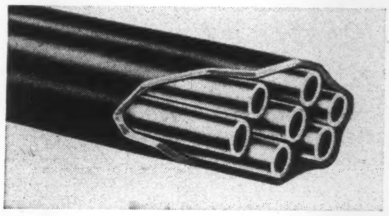
For more data circle MD 12, Page 217

NEW PARTS AND MATERIALS

TUBING HARNESS 13

. . . carries bundles of instrument tubing

Samuel Moore & Co., Dekoron Tubing Div., Mantua, O.



Tubing is impervious to attack by moisture or corrosive atmospheres.

Designation: Impervapak Metl-Cor.

Size: ¼ or ⅜-in. tubes; $\frac{1}{16}$-in. thick sheath; lengths to 50 ft.

Service: As instrument or control lines; corrosionproof sheath protects tubing; bent easily, but sufficiently rigid to be used with few supporting brackets.

Design: 4, 7 or 10 copper or aluminum tubes over which is extruded a black polyethylene plastic sheath; standard line of pressure-tight fittings available to join successive lengths; special size tubes available.

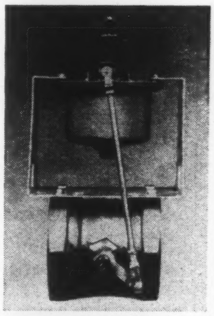
For more data circle MD 13, Page 217

BUTTERFLY VALVE 14

. . . operated by pneumatic motor

Minneapolis-Honeywell Regulator Co., Industrial Div., 5060 Wayne Ave., Minneapolis 44, Minn.

Air, water or steam flow can be controlled.



Size: 1½ to 6 in. pipe size.

Service: Controlling flow of air, water or steam at pressure to 20 psi max; temperature, 250 F max; control-air pressure range, 0 to 15 psi.

Design: Pneumatically operated butterfly; valve motor has mechanical stops to limit wing rotation; screwed connections; bronze body, wing and trim; relay for positive valve positioning on throttling control applications, optional.

For more data circle MD 14, Page 217

INSTRUMENT PANEL VIBRATOR 15

. . . prevents "sticking" of meters

Globe Industries Inc., 125 Sunrise Place, Dayton 7, O.

INSTRUMENT PANEL
SPECIFICATION NO.
DUTY—CONTINUOUS
THE GLOBE INDUSTRIES, INC.
DAYTON, OHIO

A vibration of known frequency and amplitude is introduced.

Size: Approx 1⅜ in. diam, 5 in. long; total weight, approx 10 oz.

Service: Providing shaking force of 0.85 to 3.4 lb at frequencies of 2000-3000 cycles per min from 2500 rpm rotation; can be furnished for any dc voltage; magnetically shielded; keeps out dust, moisture and salt spray; integral circuit provided to eliminate radio-frequency interference.

Design: Fractional-hp, 2-pole, 2-brush motor which rotates unbalanced weight on end of armature shaft; black anodized aluminum outer enclosure; inner enclosure is cadmium-plated steel.

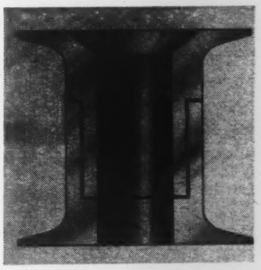
For more data circle MD 15, Page 217

SPACING FASTENER 16

. . . for sandwich or soft structures

Delron Co. Inc., 5524 Southern Ave., South Gate, Calif.

Crushing is avoided by limiting takeup of nut and bolt to a specified grip length.



Designation: Fasco.

Size: No. 8, 10 and ¼-in. screw sizes; grip lengths, $\frac{3}{16}$ to 1 in.

Service: Spacing and limiting bolt and nut travel, also attachment of conduits cables and instruments; prevents crushing of sandwich panels or soft materials; positive, aligned grip because of interference fit of 0.002 to 0.005-in. between mating parts; installed by hand with ordinary nut and bolt, or with squeezer die and index pin for faster production.

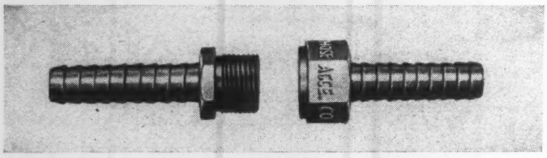
Design: Two-piece; made of 24ST aluminum alloy, anodized in specified color; other materials and sizes available.

For more data circle MD 16, Page 217

HOSE COUPLINGS 17

. . . long-shank for connection strength

Hose Accessories Co., 2704 *N.* 17*th St., Philadelphia* 32, *Pa.*



New construction method produces a leakproof coupling with no pressure losses or expensive shutdowns.

Designation: 900 BS.

Size:

Shank Length (in.)	Size IPT (in.)	Size GHT (in.)	Shank Length (in.)	Size IPT (in.)	Size GHT (in.)
¼	¼	. .	½	¼, ¾	¾
⅜	⅜, ¾	¾	¾	¾	¾

Service: For medium-pressure steam and air; satisfactory for petroleum or oil, since couplings are nonsparking; leakproof and nonporous.

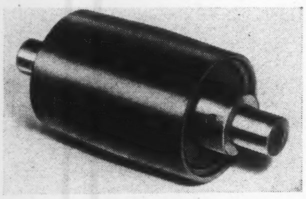
Design: Swivel type, of machined brass bar stock.

For more data circle MD 17, Page 217

IDLER ROLLERS 18

. . . mounted vertically or horizontally

Samuel Olson Mfg. Co., Inc., 2424-22 *Bloomingdale Ave., Chicago* 47, *Ill.*



Two diameters are available in these crowned rollers for lightweight power conveyors.

Size: 2⅝ or 4¼ in. diam; length to specification; ¾-in. shaft diam; ⅛-in. pipe tap in shaft ends.

Service: Carrying power-conveyor belts; can be mounted horizontally, vertically or at any angle; can be lubricated through shaft ends.

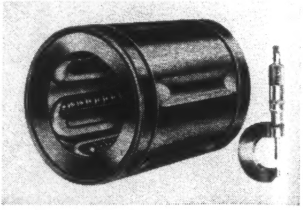
Design: Crowned idler; combination radial and thrust precision bearings with felt washer and steel washer seal, or unground split outer-race bearings with labyrinth seal; fabricated from $\frac{3}{16}$-in. wall (2⅝ in. OD) or ¼-in. wall (4¼ in. OD) seamless steel tubing; lubrication passages from shaft ends feed directly to bearing housings.

For more data circle MD 18, Page 217

BALL BUSHINGS 19

. . . guide linear motion of heavy shafts

Thomson Industries Inc., Manhasset, L. I., N. Y.



New large size is available for heavy loads or operation on large shafts.

Designation: A406080.

Size: For 2½ in. shaft; 3¾ in. OD; length, 5 in.; length between retaining rings, 3¾ in.

Service: Providing low-friction linear or reciprocating motion with static load rating of 1710 lb and rolling load rating of 1380 lb; long life with precision alignment; eliminates possibility of binding or chatter.

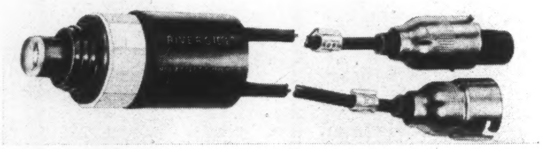
Design: Six ball circuits of $\frac{5}{16}$-in. balls ground to grade A tolerances from 52100 steel; bearing outer sleeve is machined from heat-treated 32100 steel.

For more data circle MD 19, Page 217

PUSHBUTTON SWITCH 20

. . . can operate under water

Riverside Mfg. & Electrical Supply Co., 10228 *Michigan Ave., Dearborn, Mich.*



For low-current applications, this switch is completely sealed when installed.

Size: $\frac{15}{16}$-in. diam; length, approx 2 in. (approx 1 in. behind panel); for panels up to ⅛-in. thick; ½-in. mounting hole.

Service: Rated 10 amp at 15-30 v dc or 125 v ac; will operate under water and resists salt spray, vibration and shock; temperatures from −65 to 165 F.

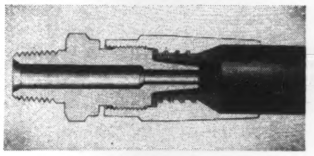
Design: Single-pole, single-throw, furnished either normally open or closed; protective cap for pushbutton end of switch screws over threaded barrel inserted through mounting hole to form tight, permanent seal; ordnance-type waterproof lead wires are vulcanized into rubber switch case; waterproof connectors can be assembled to lead wires when required.

For more data circle MD 20, Page 217

HOSE COUPLINGS 21

. . . grip hose ends with heavy clamping force

Lincoln Engineering Co., 5736 *Natural Bridge Ave., St. Louis* 20, *Mo.*



Dependence on pressure obtained by wedging hose core in the sleeve to hold hose is eliminated.

Designation: Lok-Tite.

Size and Service: Hose is held by heavy clamping pressure, holding hose tightly; fast assembly, since bell-shaped counterbore on sleeve engages wire braid on hose and acts as screw to force braid into sleeve; large-volume flow due to large flow passage in stud and short stud length; end of hose core is confined by metal, eliminating hose extrusion; reusable;

Thread	Hose Specifications				
	ID	OD	Wire	Bend	Pressure
(in.)	(in.)	(in.)	(No.)	(rad, in.)	(psi)
⅛ NPTF*	3/16	½	1	4	2500
¼ NPTF*	¼	11/16	2	4	5000
½-27†	¼	11/16	2	4	5100
⅜ NPTF*	⅜	25/32	1	5	2000
½ NPTF§	⅜	27/32	2	5	4100
½ NPTF§	½	31/32	2	7	3600

* Male. † Taper female. § Female.

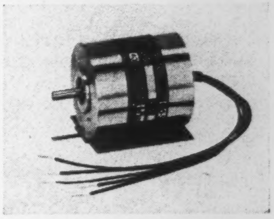
Design: Machined from steel bar stock, zinc plated; wire braid is clamped between stud shoulder and shelf on sleeve; notched to provide gage line for skiving outer cover of hose to correct length.

For more data circle MD 21, Page 217

MINIATURE SERVO MOTORS 23

. . . reliable under extreme conditions

G-M Laboratories Inc., 4300 *N. Knox Ave., Chicago* 41, *Ill.*



Intended for servo and control applications, these precision motors can be adapted to drive auxiliary equipment.

Designation: 665-50.

Size: 1.7 in. diam, 1¾ in. long; shaft extension and length to specifications.

Service: Available for 8 to 220 V, single-phase operation; temperature, −55 to 72 C; vibration, 10 to 55 cps at 0.06-in. excursion; humidity, 95% RH at 72 C; altitude, to 60,000 ft;

Frequency (cps)	Poles (No.)	No Load Speed (rpm)	Stall Torque (oz-in.)	Stall Watts (w per phase)
60	2	3300	2.0	6.0
60	4	1650	2.0	6.0
60	8	800	2.0	6.0
400	2	22,000	1.5	10.0
400	4	11,000	1.7	10.0
400	8	5500	1.9	10.0

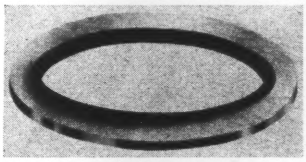
Design: Flange or ring-mounted aluminum-alloy or stainless steel housings; high-carbon or stainless-steel instrument-type ball bearings; gear train with 55:1 or other ratios available; output shaft with or without integral pinion; 800-cycle motors available.

For more data circle MD 23, Page 217

FACE SEAL 22

. . . synthetic rubber bonded to steel rim

Precision Rubber Products Corp., 3110 *Oakridge Dr., Dayton* 7, *O.*



Pressure forces sealing lips of the inner rubber seal against the surfaces to form a leakproof seal.

Designation: Dyna-Seal 110.

Size: Standard sizes as follows—larger sizes available later;

Bolt Size	Seal		Bolt Size	Seal	
	ID	OD		ID	OD
(in.)	(in.)	(in.)	(in.)	(in.)	(in.)
3/16	0.220	0.422*	⅝	0.665	1.062†
7/32	0.246	0.453*	11/16	0.727	1.157§
¼	0.280	0.516*	¾	0.800	1.266§
5/16	0.342	0.594*	13/16	0.862	1.359§
⅜	0.405	0.687*	⅞	0.925	1.453§
7/16	0.467	0.766†	15/16	0.987	1.531§
½	0.540	0.875†	1	1.050	1.656§
9/16	0.602	0.969†	1⅛	1.175	1.844§

Thickness, * 0.054-in., † 0.075-in., § 0.090-in.

Service: Sealing flat surfaces, bolt and rivet heads, flanges and special fittings against pressures to 10,000 psi; seals air, many industrial gases, petroleum products, hydraulic fluids, water and chemical solutions; temperature, −65 to 250 F; gives full bearing surface.

Design: Trapezoidal-shaped synthetic rubber sealing member, bonded to cadmium-plated cold-rolled steel rim, is compressed by mechanical face pressure to form seal that resists pulsating pressures.

For more data circle MD 22, Page 217

MINIATURE CIRCUIT BREAKERS 24

. . . fit in standard fuseholders

Mechanical Products Inc., 1824 *River St., Jackson, Mich.*

MINI-BREAKER
15

Applied as a direct replacement in existing fuse-protected circuits, this thermally actuated breaker protects against overloads and shorts.

Designation: Mini-Breaker.

Size: Fits standard Edison-base fuseholders.

Service: Providing overload and short-circuit protection; sizes for 15, 20, and 30 amp, 110-125 v ac; service is restored after interruption by pressing in and releasing shockproof reset button; trip-free —will not maintain an overload circuit; can be reset after 10-sec cooling period; carries rated current continuously at 135 F, trips at 200% load within 4 min at −50 F; passes UL tests for branch circuit breakers.

Design: Thermally actuated; on overload, a bimetal thermostat element heats up and disengages from a pair of latch plates on reset plunger; twin extension springs then pull movable contact assembly away from stationary contacts; when tripped, reset button is pushed outward to expose a groove which indicates tripped condition.

For more data circle MD 24, Page 217

NEW PARTS AND MATERIALS

SEALED STARTERS

25

. . . exclude dust, lint and dampness

Square D Co., 4041 *N. Richards St., Milwaukee* 12, *Wis.*

Designed particularly for textile industry applications, these starters feature a "lint-tight" enclosure with a neoprene sealing gasket.

Designation: Class 2510.

Size and Service: For up to 600 v ac or 250 v dc; size 0 starters rated 15 amp, size 1, 25 amp (open ratings); sealed against dust, lint and high humidity; toggle mechanism is not affected by vibration; trip-free, so that contacts cannot be held closed against overload; melting-alloy type, inverse time thermal overload relays;

Poles (No.)	Size§	Rating (v)	Rating (hp)*	Rating (hp)†
2	0	115	...	1
		230	...	1½
2	1	115	...	1½
		230	...	3
3	0	110	1½	1
		208–220	2	1½
		440–550	2	1½
3	1	110	3	1½
3	1	208–220	5	3
		440–550	7½	5
4	0	110	1½	..
		208–220	2	..
		440–550	2	..
4	1	110	3	..
		208–220	5	..
		440–550	...	..

*Polyphase. †Single-phase. §NEMA.

Design: Toggle operated with double-break silver contacts; size 0 starters have binder-head screws, size 1—solderless connectors; sheet-steel enclosure with over-center latch provides heavy clamping pressure on neoprene sealing gasket; open types, general purpose enclosures, manual types, and single or double mounting pedestals are available.

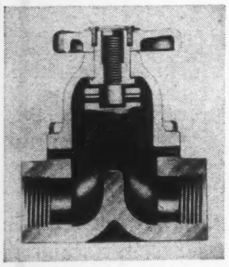
For more data circle MD 25, Page 217

DIAPHRAGM VALVES

26

. . . in chemical-resistant plastic

American Hard Rubber Co., 93 *Worth St., New York* 13, *N. Y.*



Metal or lubricant never comes in contact with the liquids handled.

Size: ½, ¾, 1, 1¼, 1½ and 2 in. standard pipe thread.

Service: Handling corrosive liquids, chemicals and food products; working pressure, 50 psi at 77 F; nontoxic and will not impart odor or taste; leak-tight closure against pressure or vacuum; chemical resistance as follows, with first letter representing Parian valve, second Saran valve*;

Sulphuric (con.)	G, G
Sulphuric (60%)	G, E
Sulphuric (10-30%)	E, E
Hydrochloric (10-37%)	G, E
Nitric (70%)	U, G
Nitric (10%)	F, E
Acetic (glacial)	U, E
Acetic (10%)	P-F, E
Hydrofluoric (48%)	F-G, E
Oleic (conc.)	U, E
Sod. hydrox. (10-50%)	G, G
Ethyl alcohol	G, E
Acetone	G, F
Carbon tetrachloride	U, G
"Ethyl" gas	U, E
Benzene	U, F
Xylene	F, G
Lube oil	U, E
Calcium chloride	E, E
Calc. hypochlorite	E, E
Ferric sulphate (15%)	E, G
Linseed oil	F, E
Sat. salt water	E, E

* E—excellent. G—good. F—fair. P—poor. U—unsuitable.

Design: Saunders diaphragm; valve body of Parian, a polyethylene plastic, or Saran; diaphragm, of rubber, neoprene or polyethylene, is fastened to compressor by molded stud; bonnet assembly is sealed off without packing gland.

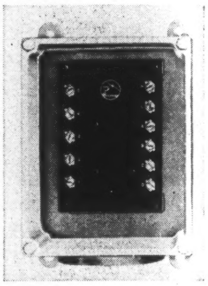
For more data circle MD 26, Page 217

LIQUID-LEVEL CONTROL

27

. . . for electrically conductive liquids

Photoswitch Inc., 77 *Broadway, Cambridge* 42, *Mass.*



Four degrees of sensitivity are provided for use with different liquids.

Designation: 10CB1.

Size: Control housing, approx 6 in. wide, 9 in. high, 4½ in. deep.

Service: Control of liquid level; accuracy independent of temperature and pressure; may be used for single-level or high and low level indication; will distinguish between liquid and foam or saturated vapor above liquid; available for 115 or 230 v; 50-60 cycles ac; relay contact ratings, 2 amp at 115 v ac, 1 amp at 230 v; will operate from probe-circuit resistance up to 3500 ohm; needs no maintenance; sensitivity ranges as follows;

Resistivity (ohm/cm³)	Voltage (max)	Current (amp, max)	Fluids
2-20	1	0.200	Concentrated acids, bases, salts
20-200	3	0.065	Dilute acids
200-2000	9	0.030	Organic liquids
2000-20,000	27	0.006	Tap water

Design: Contact of liquid with one of 6 available types of probes causes probe circuit to operate single-pole, double-throw relay through a transformer and rectifier; nonelectronic; weather-resistant or watertight housings available.

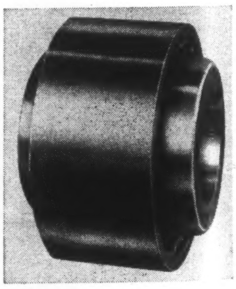
For more data circle MD 27, Page 217

FLEXIBLE COUPLINGS

28

. . . gear type in standard sizes

Cone-Drive Gears Div., Michigan Tool Co., 7171 *E. McNichols Rd., Detroit* 12, *Mich.*



Having only 7 parts, these couplings are sealed to hold in lubricant and exclude dirt.

Designation, Size and Service: For coupling shafts with average of 3 deg annular misalignment and $\frac{1}{16}$-in. offset, depending on size; sealed to keep lubricant in, keep dirt out; easy to assemble and disassemble;

Part No.	Bore (in.)	Speed (thousand rpm)	Capacity (hp at 100 rpm)
700120	¾, 1, 1⅛, 1¼	25	4
701160	1½, 1⅝	21	12
702210	1¾, 1⅞, 2, 2⅛	18	24
703260	2¼, 2⅜, 2⅝	14	41
704310	2¾, 2⅞, 3	12.2	76
705360	3¼, 3⅜, 3½	10.6	119
706410	4	9.4	190
708550	5½	7.5	410
710650	6½	6.5	550

Design: Gear-type flexible; consists of 2 hubs and sleeve made of forged SAE 1045 steel plus 2 neoprene seals and 2 snap rings; teeth are cut with minimum backlash; mill-motor, spacer, vertical-shaft and floating-shaft couplings, as well as other bores, larger sizes and special types, are available.

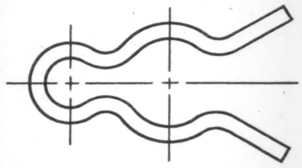
For more data circle MD 28, Page 217

NEW PARTS AND MATERIALS

RETAINER SPRINGS 29

. . . snap into shaft grooves

Precision Spring Corp., Three Rivers Div., 800 *W. Broadway, Three Rivers, Mich.*



These springs may be substituted for cotter pins, locknuts, etc.

Designation: 21A.

Size:

Shaft Groove Diam (in.)			Shaft Groove Rad (in.)	Spring Diam (respectively) (free position, in.)			Spring Wire Size (in.)
3/32,	⅛,	3/16	0.018	1/16,	3/32,	5/32	0.026
¼,	5/16,	⅜	0.036	7/32,	9/32,	11/32	0.062
7/16,	½,	9/16	0.058	13/32,	15/32,	17/32	0.106
⅝,	11/16,	¾	0.073	19/32,	21/32,	23/32	0.135
13/16,	⅞,	15/16	0.094	25/32,	27/32,	29/32	0.177

Service: As retainers on shafts; withstand repeated assembly and disassembly.

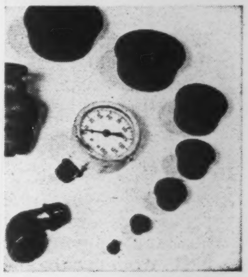
Design: "Hairpin" type of SAE 1065 spring-steel wire, tempered and oiled; Parkerized finish or cadmium plating available.

For more data circle MD 29, Page 217

CAPS AND PLUGS 31

. . . push on or into ports, pipes or holes

CaPlugs Div., Protective Closures Co. Inc., 1872 *Genesee St., Buffalo* 11, *N. Y.*



Tough and flexible, these plastic caps are used as dust and moisture seals or shipping protectors.

Designation and Size: 1/32-in. thick; special sizes to 3 11/16 in. OD; standard sizes as follows;

Size	Plug (diam, in.)	Cap (diam, in.)	Size	Plug (diam, in.)	Cap (diam, in.)
00	⅛-11/64	1/16-7/64	8	43/64-47/64	39/64-43/64
0	3/16-15/64	⅛-11/64	9	23/32-51/64	21/32-47/64
1	¼-19/64	3/16-15/64	10	25/32-55/64	47/64-51/64
2	5/16-23/64	¼-19/64	11	27/32-59/64	25/32-⅞
2X	11/32-25/64	9/32-21/64	12	29/32-63/64	27/32-15/16
3	⅜-27/64	5/16-23/64	13	63/64-1 7/64	59/64-1 1/16
4	7/16-31/64	⅜-27/64	14	1⅛-1 15/64	1 1/16-1 3/16
5	½-35/64	7/16-31/64	15	1¼-1 23/64	1 3/16-1 5/16
6	9/16-39/64	½-35/64	16	1 23/64-1 31/64	1 19/64-1 7/16
7	39/64-43/64	35/64-39/64	17	1 31/64-1 39/64	1 7/16-1 9/16

Service: Protective closure for pipes, ports or holes; inert to all common chemical agents, vermin and fungusproof; keeps shape to 220 F if unstressed, 185 F if stressed; remains flexible to —94 F; leaves little deposit on threads.

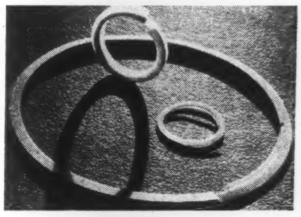
Design: Molded from red polyethylene plastic; special designs available.

For more data circle MD 31, Page 217

BACKUP RINGS 30

. . . protect O-rings from extrusion

W. S. Shamban & Co., 5745 *Marilyn Ave., Culver City, Calif.*



Chemically inert, this packing has low friction.

Designation: Kelon-T.

Size: Continuous spiral from 0.125 to 15.5 in. ID, corresponding to sizes of standard O-rings.

Service: Protects O-ring seal from extrusion, deterioration or loss of efficiency; chemically inert and unaffected by oils, acids, bases or solvents; temperatures from −110 to 500 F; will not shrink, swell, harden or soften; low friction; can seal effectively without O-rings if packing completely fills groove in continuous spiral.

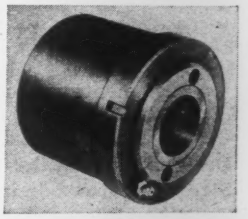
Design: Continuous spiral made of Teflon.

For more data circle MD 30, Page 217

PILOT BUSHINGS 32

. . . with sealed tapered roller bearings

J. G. Jergens Co., 11106 *Avon Ave., Cleveland* 5, *O.*



Adjustable for wear, these bushings are sealed against grit or dust.

Designation and Size:

No.	ID (in.)	OD* (in.)	Length† (in.)	No.	ID (in.)	OD (in.)	Length (in.)
B-204	½	1⅞	1.62	B-215	1¾	4⅛	2.50
B-205	9/16	2	1.62	B-216	1⅞	4½	2.88
B-206	⅝	2 5/16	1.84	B-217	2	4⅝	2.94
B-207	¾	2½	1.81	B-218	2⅛	5	2.88
B-208	15/16	2¾	1.88	B-219	2¼	5⅛	2.88
B-209	1	2¾	1.88	B-220	2⅜	5¼	3.06
B-210	1⅛	3 3/16	2.56	B-221	2¾	5⅜	3.06
B-211	1¼	3 3/16	2.56	B-222	3	6⅜	3.75
B-212	1 5/16	3⅜	2.44	B-223	3½	7¼	4.00
B-213	1½	3⅝	2.44	B-224	3¾	7¼	4.00
B-214	1 11/16	3⅞	2.50	B-225	4	8	4.25

* Barrel size—supplied approx 0.020-in. oversize for grinding to fit. † Mounting length, excluding shoulder.

Service: Precision location and bearing for shafts; takes thrust and radial loads; sealed against grit or dust; bearings can be adjusted to compensate for wear.

Design: Pilot tapered-roller; 2 Timken bearings; removable slip bushings, keys and keyways can be used; lubrication fitting feeds to annular space between bearings.

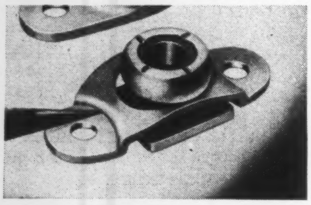
For more data circle MD 32, Page 217

NEW PARTS AND MATERIALS

FLOATING ANCHOR NUT 33

. . . locks bolt with positive grip

Elastic Stop Nut Corp. of America, 2330 Vauxhall Rd., Union, N. J.



Weight savings of 1.3 lb per 1000 pieces are claimed over earlier anchor nuts of this type.

Designation: A-41.

Size and Service: Simplified assembly, since lining up of bolt and nut is quicker; permits assembly in small spaces; grips bolt under vibration and impact loading; complies with dimensional and performance requirements of AN366 and AN-N-5; floats 0.054-in. lengthwise, 0.049-in. sideways;

Thread	Length (in.)	Width (in.)	Height (in.)	Weight (lb/100)	Strength (axial, lb)
8-32 NC	0.969	0.359	0.281	0.68	1720
10-32 NF	0.969	0.385	0.281	0.68	2460

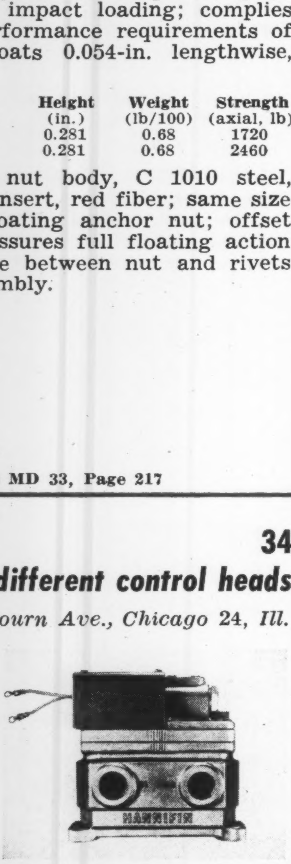
Design: Two-lug floating; nut body, C 1010 steel, cadmium plated; locking insert, red fiber; same size as firm's standard nonfloating anchor nut; offset shoulder on anchor lug assures full floating action by preventing interference between nut and rivets holding lug to part or assembly.

For more data circle MD 33, Page 217

FOUR-WAY VALVE 34

. . . available with 3 different control heads

Hannifin Corp., 1116 S. Kilbourn Ave., Chicago 24, Ill.



Operation can be by a remote pilot valve, spring-return solenoid, or momentary contact solenoid.

Designation: BB-1, -2, -4.

Size: ⅜, ½ and ¾-in.

Service: Pressures from 15 to 150 psig; can be modified for higher or lower pressures, or vacuum; BB-1 can be actuated by solenoid, ball-cam, palm-button, hand-toggle (locking or nonlocking), foot treadle (locking or nonlocking), mechanical toggle, overriding roller cam, or piston-operated pilot valves; BB-2 has lightly stressed stainless-steel spring for return of solenoid, with speeds up to 600 cycles per min; BB-4 head has 2 solenoids for momentary contact operation.

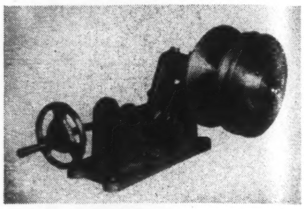
Design: 4-way; consists of two 3-way valves arranged so one operates normally closed, the other normally open; pressure within valves returns 2 piston-poppets when pilot pressure is released, eliminating springs or levers; piston-poppet assemblies (only moving parts) are identical removable and replaceable cartridge assemblies for all sizes.

For more data circle MD 34, Page 217

VARIABLE SPEED TRANSMISSION 35

. . . stepless speed changes while running

Turner Uni-Drive Co., 3416 Terrace St., Kansas City 8, Mo.



Floating wheel assembly provides perfect belt alignment in any position or speed.

Designation: TeeCo.

Size and Service: Infinite speed changes while running; belt is aligned in any position or speed;

Model	Rating (hp)	PD Min (in.)	PD Max (in.)	Total Ratio	V-belt (Section)
3A	1	1.32	1.73	3:1	A
3B	2	1.82	1.73	3:1	B
8A	2	1.85	2.83	8:1	A
8B	3	2.3	2.83	8:1	B

Design: Turning adjusting wheel moves arm to change tension on belts, and shifts middle faces of sheaves to change pitch diameters; aluminum construction with bronze bearings.

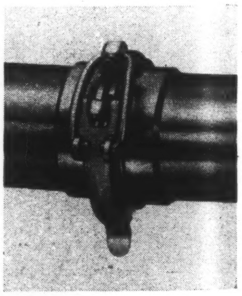
Application: Machine tools; printing presses; folders; food-processing machines; fans; assembly conveyors; testing equipment.

For more data circle MD 35, Page 217

SANITARY FITTINGS 36

. . . disassembled with "flick of the wrist"

Tri-Clover Machine Co., Kenosha, Wis.



Fittings are joined with snap-open clamps, permitting easy assembly and disassembly for cleaning.

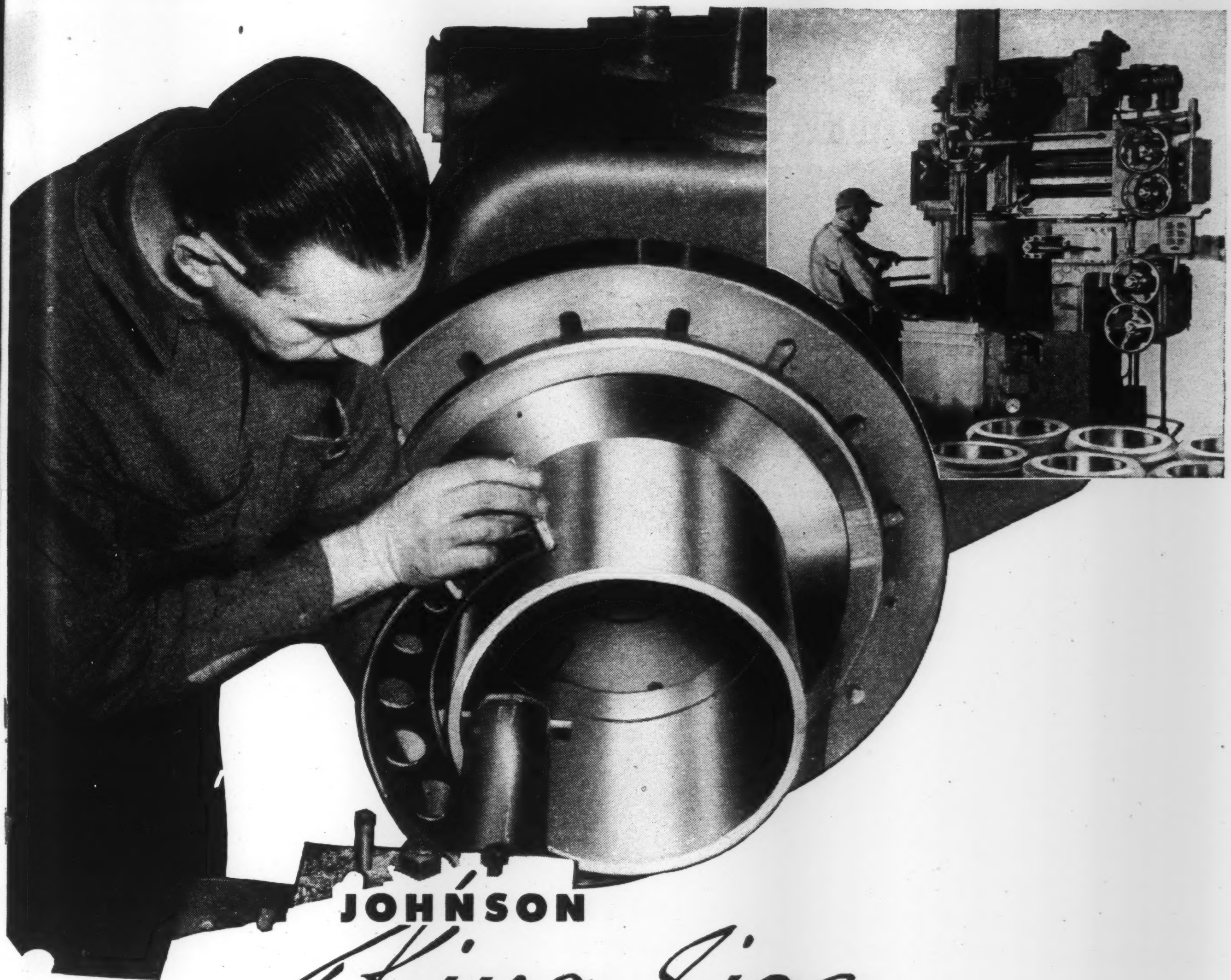
Designation: Tri-Clamp.

Size: For 1½, 2, 2½, 3 and 4 in. sizes.

Service: For permanent and take-down sanitary fitting lines; saves installation and cleaning time; leakproof; make flush, sanitary joints; nontoxic, fat-resistant gaskets; withstand up to 100 psi pressures.

Design: Flange type ferrule fittings with precision-molded Hycar gaskets which fits into proved ferrule lip; spring clamp, which grips ferrule edges, is closed by a snap-action toggle of 2 types, one for hand operation, the other (with short toggle) for operation by special hand tool; fabricated of type 304 stainless steel; expanding and welding-type ferrules, ells, tees, Y's, crosses, unions, reducers, adapters are available, also pumps and valves with same fittings.

For more data circle MD 36, Page 217



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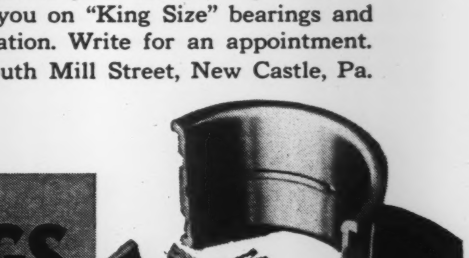


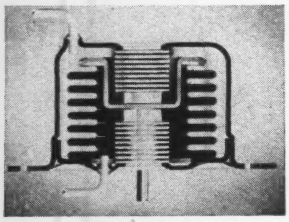
NEW PARTS AND MATERIALS

DIFFERENTIAL PRESSURE BELLOWS 37

. . . actuates switches, valves or controls

Clifford Mfg. Co., 152 *Grove St., Waltham* 54, *Mass.*

Originally developed for jet plane fuel systems, this bellows assembly can be used for pressure or flow control.



Size: To specifications; 2½ to 3 in. diam sizes considered preferred.

Service: Providing motion of rod upon change in differential pressure across main bellows; can actuate switches, valves, levers, cams or controls; up to 500 psi differential pressure, or greater if special; can be used for flow indication by measuring pressure drop across orifice or venturi.

Design: Single unit composed of brass, stainless-steel or Monel main bellows with 2 bellows as flexible seals.

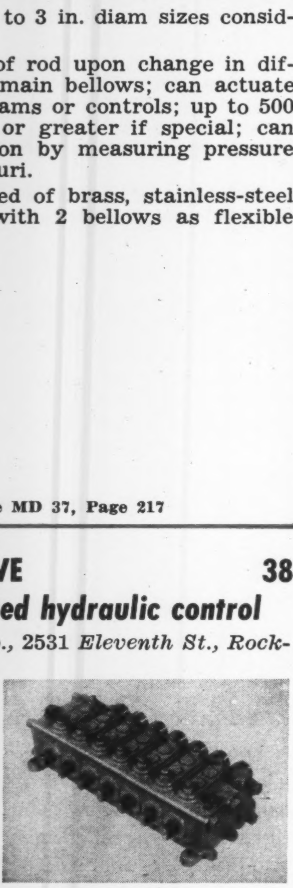
For more data circle MD 37, Page 217

MULTIPLE-SECTION VALVE 38

. . . provides centralized hydraulic control

Sundstrand Machine Tool Co., 2531 *Eleventh St., Rockford, Ill.*

Devices can be actuated simultaneously under full or varying load, providing the total load does not exceed the relief valve setting.



Designation: S-25.

Size: ¾-in. NPTF ports.

Service: Rated 25 gpm with max operating pressure of 1500 psi; positive cylinder control, since check valves are included in each section.

Design: 3 and 4-way; 10 sections or less may be assembled in one stack in any sequence with exceptions as noted; O-ring seals between sections—permitting addition of sections at later date;

Type	Section	Description
Inlet plate	R	Integral relief, adjustable 500-1500 psi
	W	Used when relief valve provided elsewhere
4-way	F	3-position, spring-centered, 90 lb pull
	H	3-position, spring-centered, 60 lb pull
	B	3-position detent
3-way	T	3-position, spring-centered series, 90 lb pull*
	A	3-position, spring-centered parallel, 90 lb pull†
Outlet plate	D	Direct return to tank
	E	Separate spring-pressure drain to allow back pressure in return
	G	Pressure to subsequent stack; provides relief and spring-chamber drain
	J	For use with A section, parallel, 3-way

---

*Shifting stem to *raise* position makes succeeding sections inoperative. †Must be last with other A sections at end of stack, and must have J outlet plate.

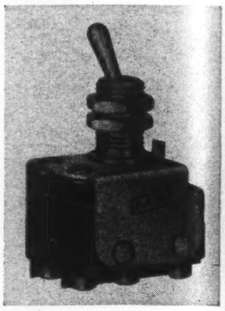
For more data circle MD 38, Page 217

SMALL TOGGLE SWITCHES 39

. . . for precise switching in small space

Micro Switch Div., Minneapolis Honeywell Regulator Co., Freeport, Ill.

Basic assembly consists of a toggle mechanism plus 1 or 2 Micro switches.



Designation: 6AT1, 6AT2, 6AT3, 6AT4.

Size: $\frac{25}{32}$-in. long, 1$\frac{21}{64}$ in. high; 6AT1 and 2, $\frac{25}{64}$-in. wide, weigh 0.02-lb; 6AT3 and 4, $\frac{21}{32}$-in. wide, weigh 0.03-lb.

Service: Rated 2 amp, 30 v dc for resistive, motor or inductive load at sea level, 1½ amp 30 v dc at 50,000 ft; 5 amp at 125 or 250 v ac; operating force, approx. 0.5-lb; travel, 40 deg min; double-throw arrangements are nonsimultaneous.

Design: Miniature snap-action switches riveted to stainless-steel toggle bracket; 6AT1 and 2 are single-pole, double throw; 2 and 4 are double-pole, double throw; toggle bushings are threaded and fitted with hex nuts for panel mounting; detents provided in both switch positions; 6AT1 and 4 are for flush mounting, 2 and 3 have positioning tabs.

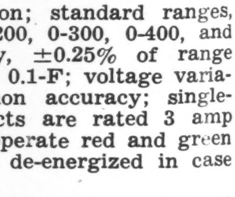
For more data circle MD 39, Page 217

TEMPERATURE CONTROLLER 40

. . . measures deviations of 0.1-F

Thermo Electric Co. Inc., Fair Lawn, N. J.

Signal lights show closure of control relay.



Designation: L-10009.

Size: Case, 10 in. wide, 12 in. high, 9 in. deep; 14.4 in. scale length.

Service: Detecting temperature variation and controlling heater elements, motor starters and electric valves; single or duplex control action; standard ranges, −100 to + 100 F, 0-100, 0-200, 0-300, 0-400, and 0-600 F; calibration accuracy, ±0.25% of range span; actuates on deviation of 0.1-F; voltage variations do not impair calibration accuracy; single-pole double-throw load contacts are rated 3 amp at 115 v ac; signal contacts operate red and green pilot lights on door; relay is de-energized in case of instrument or tube failure.

Design: Null-balance ac Wheatstone bridge controlled by slidewire dial with 10:1 vernier drive; bridge unbalance voltage is amplified electronically to operate relay; welded steel case with gasketed aluminum door, moistureproof and dust-tight, for flush panel or wall mounting.

For more data circle MD 40, Page 217

Contact **KAYDON** of Muskegon

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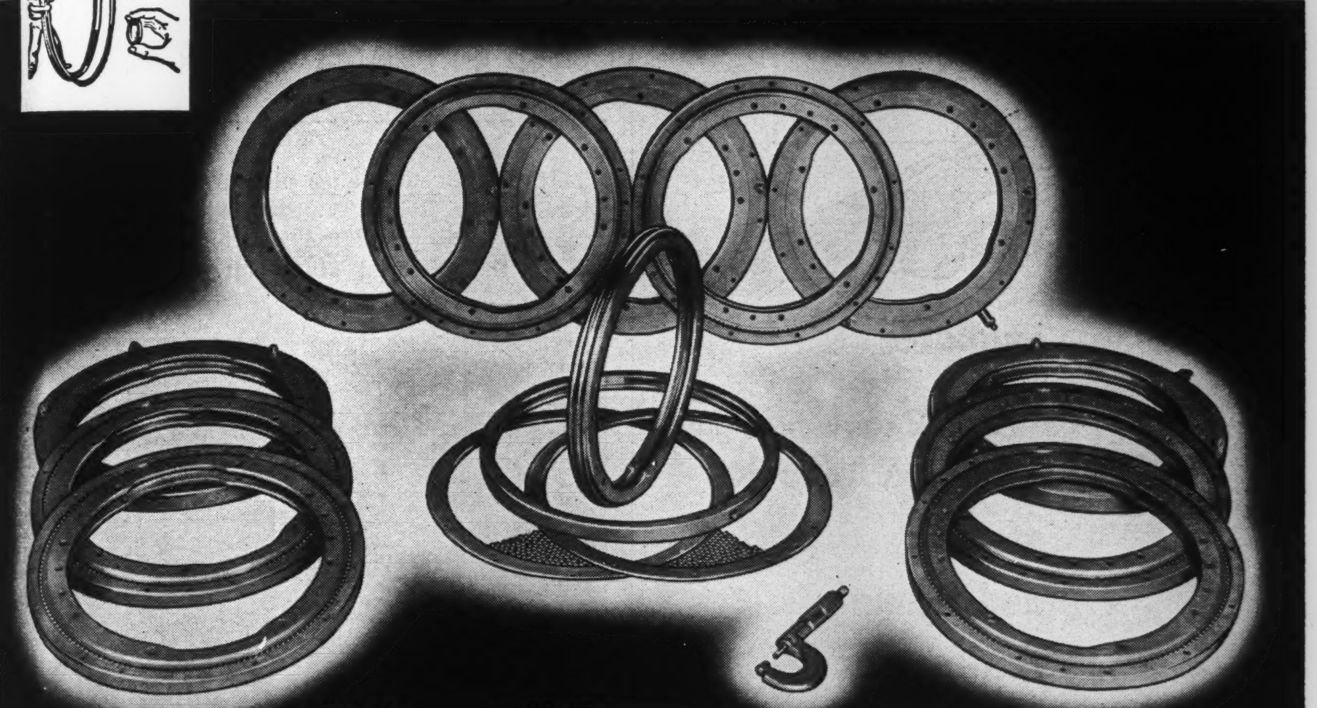

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8.062" x 10.687" x .750"

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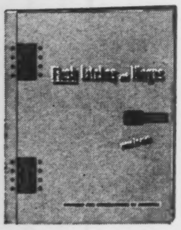

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MEN

OF MACHINES

MACHINE DESIGN takes pleasure in announcing th promotion of **Robert L. Stedfeld** to the position o Associate Editor and the addition of **Keith A. Carlson** to the editorial staff. Mr. Carlson began hi duties as Assistant Editor on August 25. This month's "Over the Board" columns on Page 4 discuss these appointments in detail.

Robert L. Stedfeld

Keith A. Carlson

◆

New assistant director of the Borg-Warner Research Laboratory in Bellwood, Ill., is **Carl R. Freberg.** Dr. Freberg was formerly in charge of the Equipment Research Department of the Naval Civil Engineering Research and Evaluation Laboratory at Port Hueneme, Calif. He also has headed the Industrial Engineering Division of the Southern Research Institute in Birmingham, Ala., and has served as a research engineer for Carrier Corp.

◆

Formerly chief engineer, **W. Ray Spiller** has been appointed to the post of vice president for engineering of the Harris-Seybold Co., Cleveland.

◆

East Coast Aeronautics Inc., a subsidiary of Barium Steel Corp., located in Pelham Manor, N. Y., has appointed **J. P. Donald Garges** as vice president of engineering and assistant general manager. Mr. Garges has held the position of chief engineer with this company since 1948 and altogether has had over 20 years of experience in the aircraft industry. He

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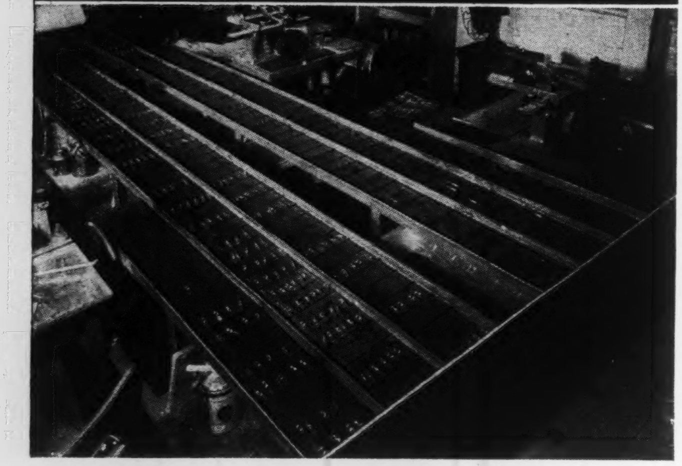
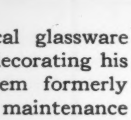


A large producer of medical and biological glassware wanted to boost capacity and efficiency in decorating his product. The cumbersome, two-pass system formerly used required excessive handling, forced high maintenance costs on special fire clay holders, held production rates far below customer demand.

Cambridge engineers, working with the customer's staff, designed the special 6 lane woven wire conveyor belt installation shown above. Ware to be fired is placed on the belt from six decorating stations at the feed ends of the belts. The moving belts carry it through a standard one-pass decorating lehr at 1200° F., completely eliminating manual handling during firing. Also, specially crimped rods mounted across the belt to hold the ware eliminate the need for fire clay holders. Oxidation resistant alloy wire used in weaving the belt reduces marking of the ware. Open mesh of the belt permits free heat circulation within the lehr, assures uniform production, minimizes rejects.

By actual comparison, this Cambridge belt installation allows 3 operators to service 6 loading stations, whereas the former method required 4 operators for only 5 stations!

Whether you're processing ceramic products, foods, chemicals or metal parts, a Cambridge Woven Wire Conveyor Belt can help combine movement with processing to reduce costs, increase uniformity, speed production. Call in your Cambridge field engineer soon to discuss your process in detail. Rely on his experienced advice. Write direct, or see "Belting-Mechanical" in your classified telephone book.



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FREE REFERENCE MANUAL describes Cambridge belts for your industry, gives conveyor design and metallurgical data. Write for yours now.

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Men of Machines

has served as chief engineer for both the Personal Planes Div. of Fairchild Engine and Airplane Corp. and the Eastern Aicraft Div. of General Motors Corp.

◆

Alexander R. Lindsay, chief engineer of the automotive division of Budd Co., Philadelphia, was recently named to succeed **Maj. Gen. G. M. Barnes,** U.S.A. (ret.), who is retiring as vice president in charge of research and engineering.

◆

Veteran RCA engineer and pioneer in radio and television, **Edward Stanko** has been appointed to the newly created post of manager of engineering, technical production division, RCA Service Co. Inc. Mr. Stanko will direct specialized training of field personnel, preparation of technical information, and development of new and improved methods for installation and servicing of RCA technical products.

◆

Otto Jahek has been promoted to manager of the department of special development for Fritz Fischer Inc., New York.

◆

Recent changes in the technical staff of the Continental Screw Co., New Bedford, Mass., include the appointment of **Harvey F. Phipard Jr.** to the position of director of research and engineering and **Edward J. Locke Jr.** as chief engineer.

◆

Martin George has been appointed chief engineer of the design and development division of Columbian Vise & Mfg. Co., Cleveland.

◆

The Franklin Institute of the state of Pennsylvania has awarded its Certificate of Merit to **Arthur M. Stoner** for his development of a chuck and collet combination for lathes to hold cylindrical work during machining. Mr. Stoner, vice president in charge of engineering of The Jacobs Mfg. Co., West Hartford, Conn., will receive the award at the Institute's Medal Day ceremonies in Franklin Hall on October 15.

◆

Herbert B. Hummer has been appointed director of research for the Durametallic Corp., Kalamazoo, Mich.

◆

The entire engineering section of Carboloy Department of General Electric Co., Detroit, has been expanded to meet the increased engineering needs of the department, which has broadened the scope of its activities in the field of man-made metals. The expansion provides for advanced metals development, process and product development, application engineering, and production engineering. Named to new posts in the organization are **E. W. Engle,** product and process engineering manager; **E. E. George,** design and application engineering manager; **R. A. Canning,** pro-

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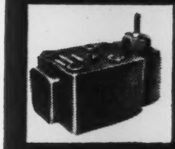
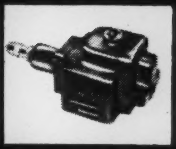
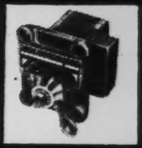
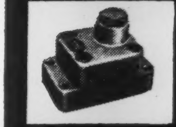
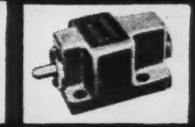
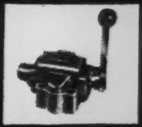
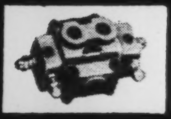

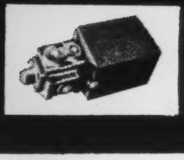
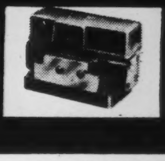

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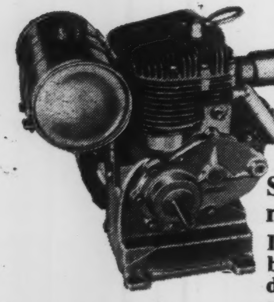

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duction engineering manager; and **R. L. Brownlee,** administrative engineer. Mr. Engle was formerly manager of process engineering; Mr. Canning, manager of service engineering; and Mr. Brownlee, manager of production at the Carboloy plant in Detroit. Mr. George was formerly manager of permanent-magnet engineering with headquarters in Schenectady, N. Y.

◆

Forrest S. Mabry was recently appointed engineering manager of the Electronics Div. plant of Westinghouse Electric Corp. in Baltimore.

◆

Vice president in charge of engineering since 1942, **George H. Acker** has been elected executive vice president of Cleveland Worm & Gear Co., Cleveland, and of its subsidiary, Farval Corp.

◆

Donald Benson has been appointed chief engineer in charge of the newly formed engineering research and development division of the Toro Mfg. Co. in Minneapolis.

◆

Illinois Institute of Technology, Chicago, recently appointed **Martin A. Elliott,** former chief of the synthetic fuels research branch at the U. S. Bureau of Mines, Pittsburgh, to the post of research professor of mechanical engineering.

◆

Samuel Sloan Auchincloss has been named executive vice president of DeWalt Inc., a subsidiary of American Machine & Foundry Co.

◆

Thomas B. Woersching has been named chief aerodynamicist at the Goodyear Aircraft Corp., Akron, O. He will be in charge of all aerodynamics work for the company's engineering division.

◆

Co-design Corp., Winchester, Mass., a new corporation which will engage in the engineering and manufacture of special instruments and devices, has named **Donald E. Williamson** as president. Mr. Williamson was formerly associate director of research of Baird Associates Inc.

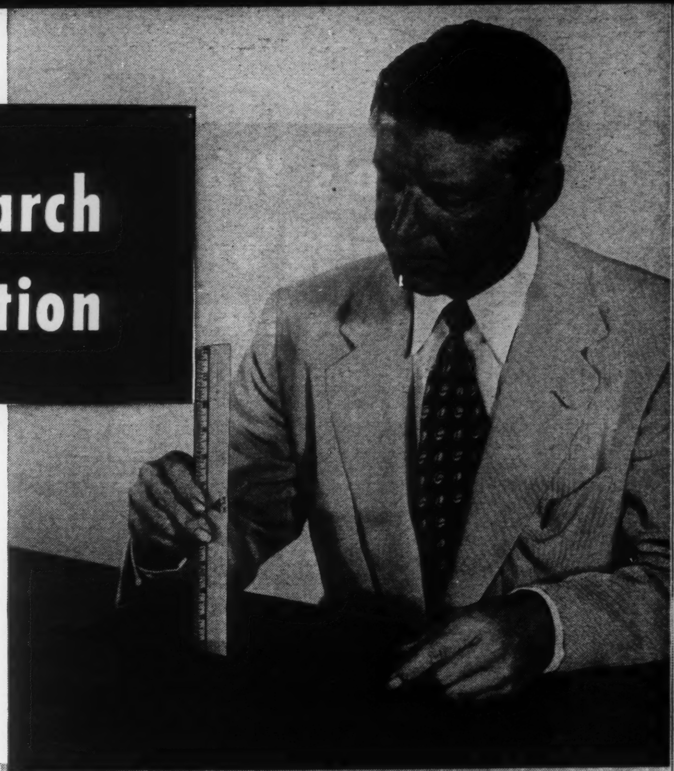
◆

The Deepfreeze Appliance Div. of Motor Products Corp., Detroit, recently announced the appointment of **Harley W. Whitmore** to the newly created post of director of engineering.

◆

To make his headquarters at the company's steel fabricating plant in Bethlehem, Pa., **John H. Porteus** has been appointed chief engineer for Luria Steel Co. He was formerly assistant chief design engineer in the machinery division of Dravo Corp.

National Engineering Research finds the *economical* solution

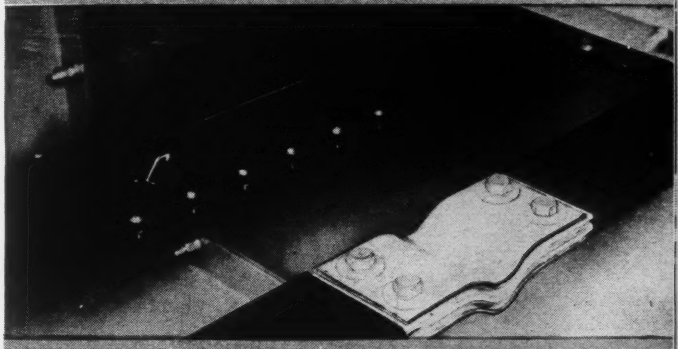


Phenolite postformed expansion joint cover.

The problem:

to insulate a 5 kilovolt, 1500 ampere bus bar installation

Recently I-T-E Circuit Breaker Company of Philadelphia had the problem of *completely* insulating 5 kilovolt, 1500 ampere 3 phase bus bar units for an Atomic Energy Commission installation. It was simple enough to insulate the bus bars with oval Phenolite tubing. But, to completely insulate the bus supports and expansion joints was a real problem. I-T-E's engineers showed us what they wanted . . . postformed Phenolite insulating covers . . . drawn deeper than anything we had ever attempted. Our engineers tackled the problem.

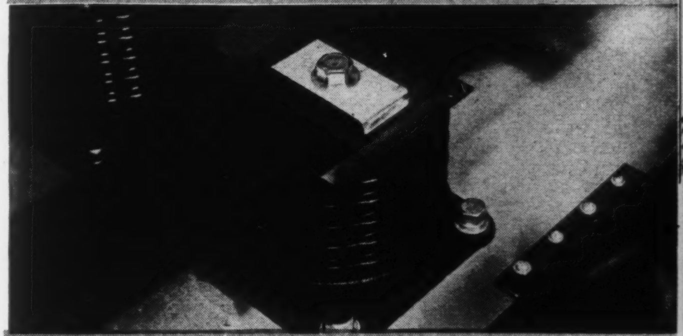


Expansion joint with and without Phenolite insulating covers.

The solution:

Phenolite Grade X-114A postforming material and National's technical "know how" in the design of forming dies

Perhaps *your* problem doesn't involve the insulation of 5 KV, 1500 ampere bus bars. But maybe you have an insulating problem where National can give you some real help in solving how to do your certain job economically. Write us, our engineering service is immediately available.



Bus support with and without Phenolite insulating covers.

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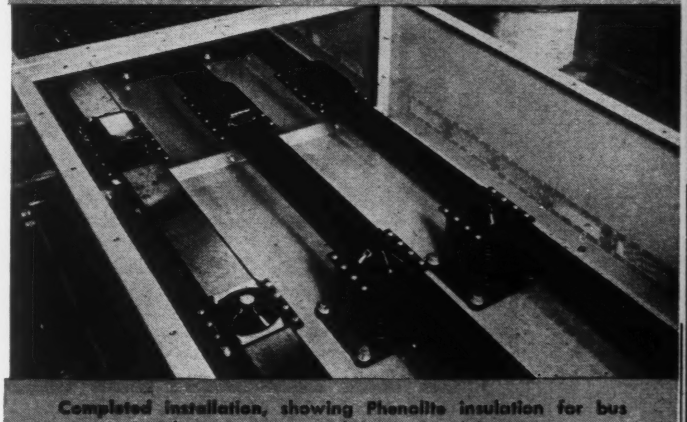
The perfect insulation material for high and low voltage applications, Phenolite possesses an unusual combination of properties. It has great mechanical strength and high resistance to moisture; ready machinability; is about one-half the weight of aluminum. Standard colors are natural, black, chocolate; mirror, semi-gloss and dull finishes. Sheets, Rods, Tubes, Special Shapes.



Completed installation, showing Phenolite insulation for bus bars, supports and expansion joints.

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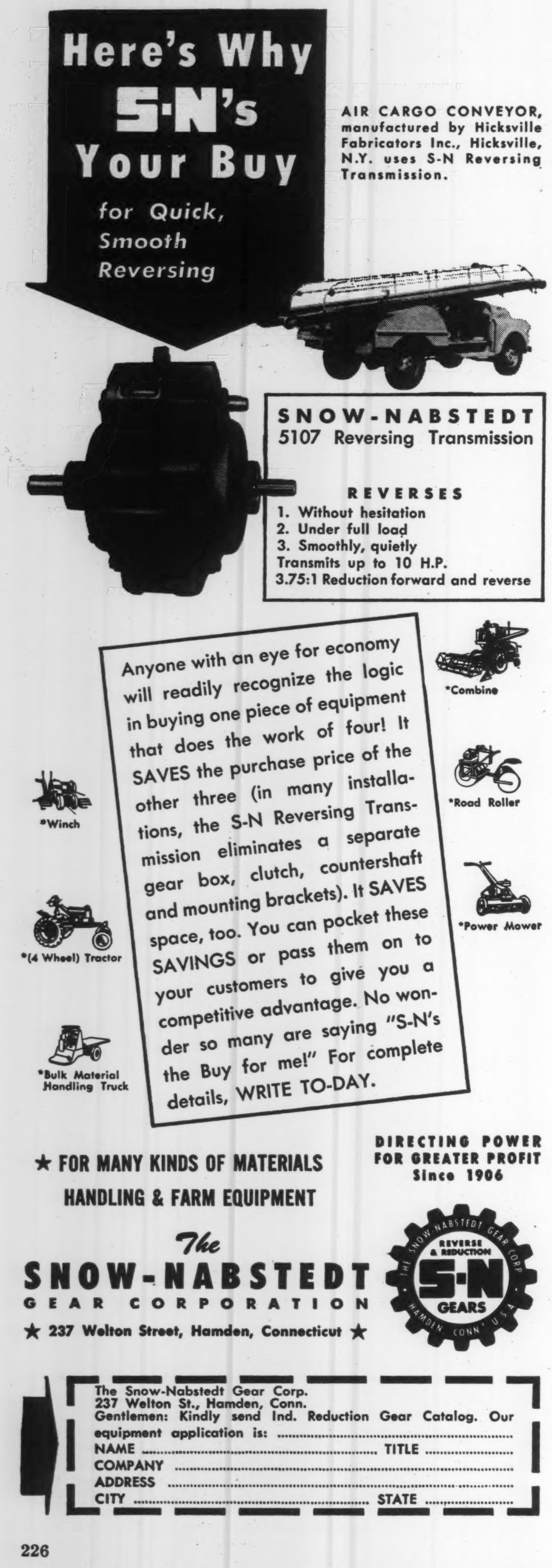

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THE ENGINEER'S Library

Recent Books

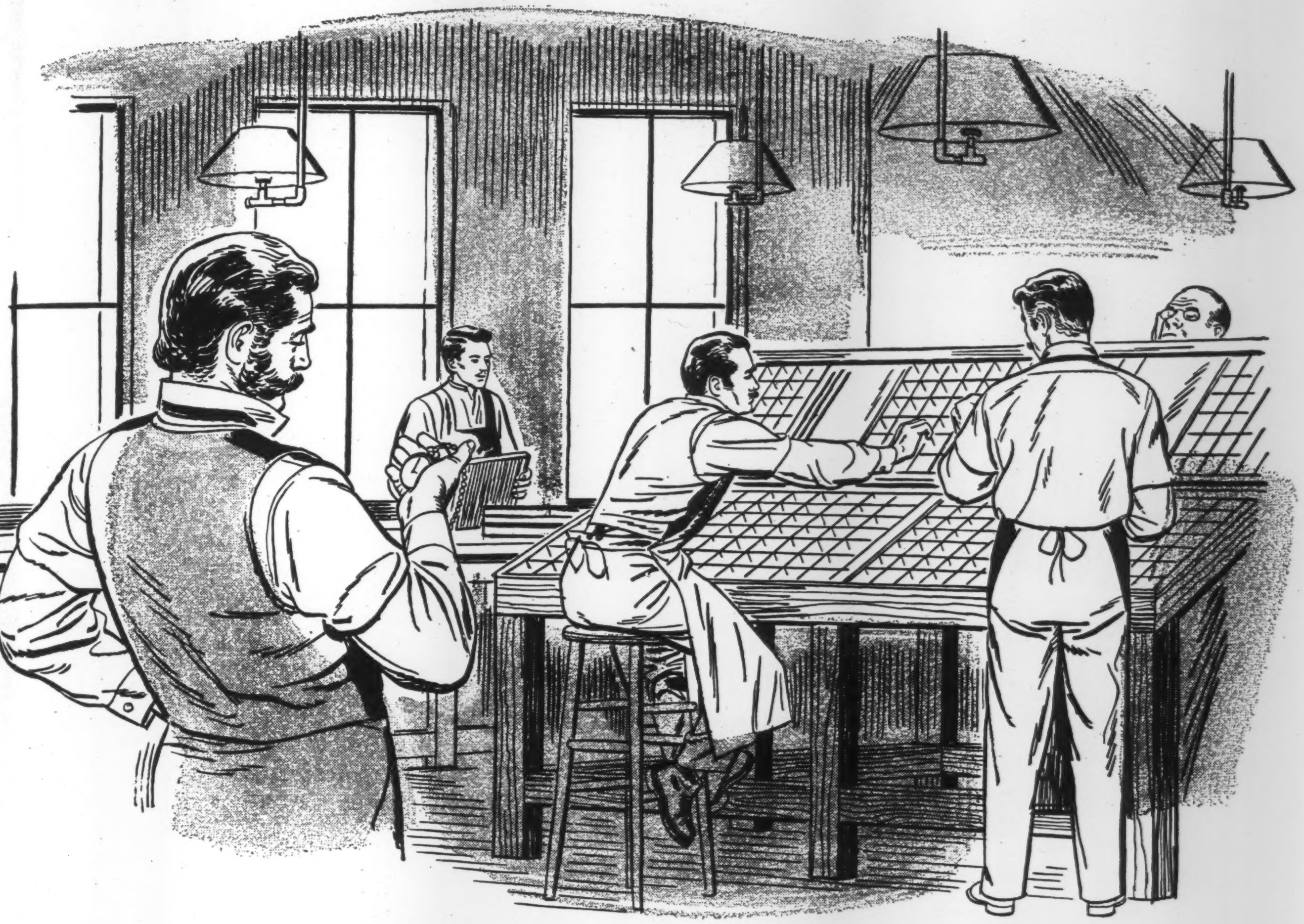
Statistical Theory with Engineering Applications. *B A. Hald, professor of statistics, University of Copenhage Denmark; 783 pages, 6½ by 10 inches, clothbound; pub lished by John Wiley & Sons Inc., New York; availabl from* MACHINE DESIGN, *$9.00 postpaid.*

The aim of this book, as explained by the author, i "to provide a fairly elementary mathematical treat ment of statistical methods of importance to the en gineer in his daily work." In accordance with thi view, the mathematical techniques employed sta within the bounds of standard differential and inte gral calculus. Applications taken from the author' experience are used throughout the text to dramatiz the significance of the theorems. In the choice o statistical methods considered, main emphasis ha been placed on the normal distribution and its relate tests because of the practical value thus obtained.

Introductory chapters deal with the calculus o probabilities and representation of observations an are followed by chapters on empirical, theoretica normal, and skew distributions. Succeeding chapter discuss limit theorems and sampling distributions distribution of the mean, x^2-distribution, distributio of the variance and the range, statistical control, dis tribution of the variance ratio, t-distribution, analysi of variance, sampling, linear regression analysis, two dimensional normal distribution, multidimensiona correlation and regression, binomial and Poisson dis tribution, multinomial distribution, and the x^2-test In the concluding chapters sequential analysis an the main points of a statistical analysis are covered To further augment the material in the text, a sep arate 97-page book of statistical tables and formula is also available.

Handbook of Engineering Fundamentals. *Edited b Ovid W. Eshbach, dean, Northwestern Technological In stitute; 1922 pages, 5½ by 8½ inches; imitation leathe bound; published by John Wiley and Sons Inc., Ne York; available from* MACHINE DESIGN, *$10.00 postpaid*

This second edition, rewritten from the origina 1936 volume, is 240 pages larger than its predecesso and represents the efforts of 39 contributors. Ob jective of the handbook is to present in a singl volume those fundamental laws and theories of sci ence which are basic to engineering practice. Mad up in 14 sections, the handbook covers mathematica and physical tables; mathematics; physical units an standards; mechanics of rigid bodies; mechanics o incompressible fluids; aerodynamics; thermodynam ics; electricity and magnetism; radiation, light, an



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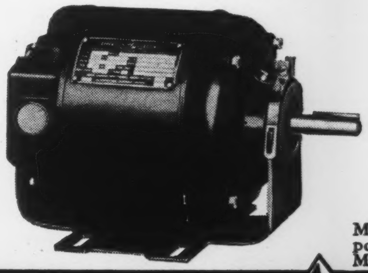

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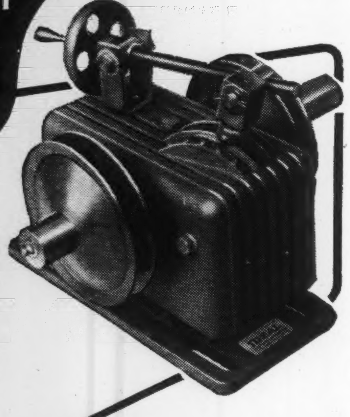

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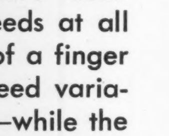

acoustics; chemistry; metallic and nonmetallic materials; and engineering law.

The Science of Flames and Furnaces. *By M. W. Thring, head of physics department, British Iron and Steel Association; 430 pages, 5½ by 8½ inches, clothbound; published by John Wiley & Sons Inc., New York; available from* MACHINE DESIGN, *$6.50 postpaid.*

Design of industrial furnaces heated by flames is the subject of this monograph. Emphasis is placed on (1) the gap between the fundamental sciences and industrial furnace design and use, (2) design diagnosis and (3) the theoretical approach to problems of furnace heating.

Cutting-Tool Materials *By Eric N. Simons; published by Sir Isaac Pitman & Sons Ltd., London; 190 pages, 5½ by 8½ inches, clothbound; available from* MACHINE DESIGN, *$4.50 postpaid.*

Steels and alloys used in cutting tools—their applications, heat treatment, and basic composition—are the subject of this descriptive English book. Beginning with a chapter on carbon tool steels, the text goes on to take up die steels, chisel steels, miscellaneous alloy tool steels, high-speed steels, and alloy steels for plastic molds and hobs. Butt-welded and atomic hydrogen-welded tools are dealt with next, followed by chapters on stellite and cemented carbides. Concluding chapters cover grinding and testing of the various materials. In addition, an extended appendix contains an alphabetical cross-referenced list of different tools with recommendations as to suitable material, compositions and heat treatments.

Application of Linear Programming to the Theory of the Firm. *By Robert Dorfman, assistant professor of economics, University of California; 108 pages, 6 by 9 inches, clothbound; available from University of California Press, Berkeley, Calif.; $3.50 postpaid.*

This monograph, prepared originally as a doctoral dissertation, applies mathematical form—the linear equation—to the planning of the firm. The method is evaluated in terms of the variables encountered in production problems. A theory of production decisions for the use of industrial engineers, industrial and economic statisticians, and production planners is presented.

Personnel Administration. *By William W. Waite, associate professor of industrial engineering, Columbia University; published by Ronald Press Co., New York; 683 pages, 6 by 9 inches, clothbound; available from* MACHINE DESIGN, *$7.00 postpaid.*

Authored by an educator who has had experience with personnel and labor relations problems as an industrial supervisor and labor arbitrator, this textbook provides a synthesis of the philosophical and

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practical approaches to personnel administration. Actual case histories are used to illustrate fundamentals and bibliographies are provided to acquaint the reader with additional collateral readings. Divided into four main parts, the book covers: starting a personnel administration program, assembling a working force, maintaining satisfactory working conditions, and providing adequate personnel relations.

Tractors and Their Power Units. *By E. L. Barger, W. M. Carleton, E. G. McKibben and Roy Bainer;* 504 *pages,* 5½ *by* 8½ *inches, clothbound; published by John Wiley & Sons Inc., New York; available from* MACHINE DESIGN, $6.50 *postpaid.*

Sponsored by the Ferguson Foundation and written on a technical engineering level, this treatise brings together and summarizes data from selected papers and bulletins on the subject of tractors and farm power. Principles and fundamentals of the mechanics and dynamics of tractor chassis are treated in detail; introductory information and descriptive material are kept to a minimum.

The Principles of the Control and Stability of Aircraft. *By W. J. Duncan, professor of aeronautics and fluid mechanics, University of Glasgow, Scotland;* 400 *pages,* 5½ *by* 8½ *inches, clothbound; published by Cambridge University Press, New York; available from* MACHINE DESIGN, $8.00 *postpaid.*

A systematic treatment of the modern concepts of stability and control in aircraft is presented. Higher branches of mathematics have been avoided; an elementary knowledge of algebra, trigonometry and calculus is sufficient for understanding.

Fuels and Combustion. *By Marion L. Smith, assistant professor of mechanical engineering, and Karl W. Stinson, professor of mechanical engineering, Ohio State University;* 348 *pages,* 6 *by* 9 *inches, clothbound; published by McGraw-Hill Book Co. Inc., New York; available from* MACHINE DESIGN, $6.50 *postpaid.*

Fundamental and factual information concerning solid, liquid, and gaseous fuels and the problems associated with their combustion are presented in this textbook.

Association Publications

Bolt, Nut and Rivet Standards. 256 *pages,* 5½ *by* 8½ *inches, imitation leather bound; available from Industrial Fasteners Institute,* 3648 *Euclid Ave., Cleveland* 15, *O.;* $3.00 *postpaid.*

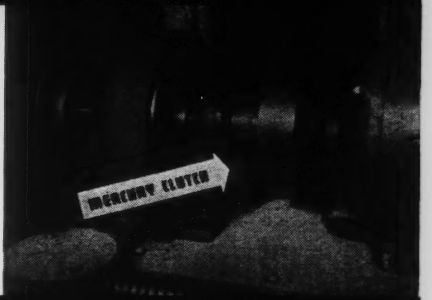
Replacing the first edition, the so-called "Red Book" which was issued in 1941, this new handbook contains all current standards for commercial fasteners. In addition, a section is included on weights, stock production sizes, recognized fastener specifications,

Case Histories that Prove the Value of Mercury Automatic Clutches . . .

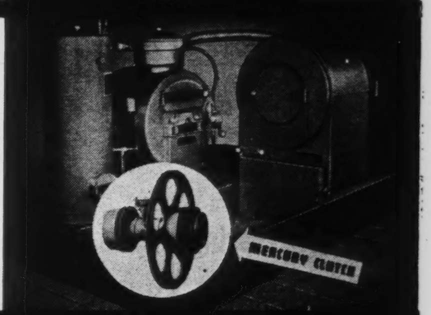
Applications

- Air Conditioning
- Aircraft
- Blowers
- Centrifuges
- Compressors
- Concrete Machinery
- Conveyors
- Cream Separators
- Door Operators
- Dry Cleaners
- Electrical Appliances
- Elevators
- Extractors
- Farm Machinery
- Food Processing Machinery
- Industrial Equipment
- Lawn Mowers
- Marine Drives
- Materials Handling
- Mixers
- Motor Generators
- Packing Machinery
- Paper Machinery
- Power Saws
- Printing Machinery
- Pumps
- Refrigeration
- Stokers
- Textile Machinery
- Washing Machines

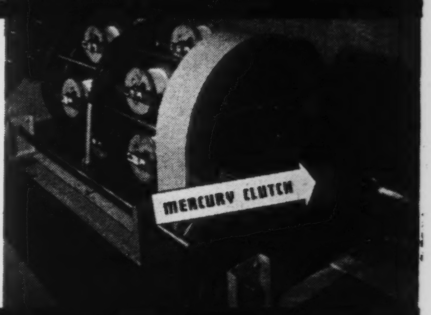
WIRE WINDER . . . A *Mercury Automatic Clutch* allows normal starting without wire breakage. In one Wisconsin plant 14 of these units are running 18 hours per day with very little maintenance. Improved production reported.



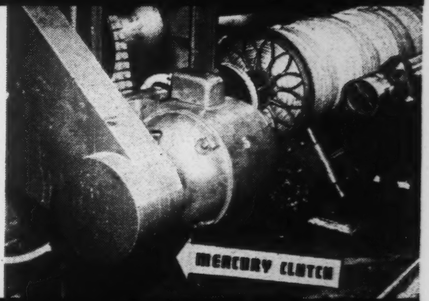
COMMERCIAL DRY CLEANER . . . A *Mercury Automatic Clutch* reduced the wattage input, avoided cycling on the starting relays, and held the motor at an efficient speed while the load was gradually accelerated. Use of clutch permitted manufacturer to redesign machine, increasing capacity 25% without increasing motor size.



12 SPOOL PLANETARY CABLER . . . A *Mercury Automatic Clutch* allows the 10 HP motor to start load-free and to operate at an efficient speed while accelerating. Motor starts the load without drawing excessive current, permitting across-the-line starting. Wire breakage greatly reduced.



HYDRAULIC BEAMER . . . The Massachusetts plant which installed this *Mercury Automatic Clutch* on a 10 HP motor reports that they have eliminated former yarn breakage due to starting with variable speed unit set for high speed operation. Clutch permits soft, gradual starting.

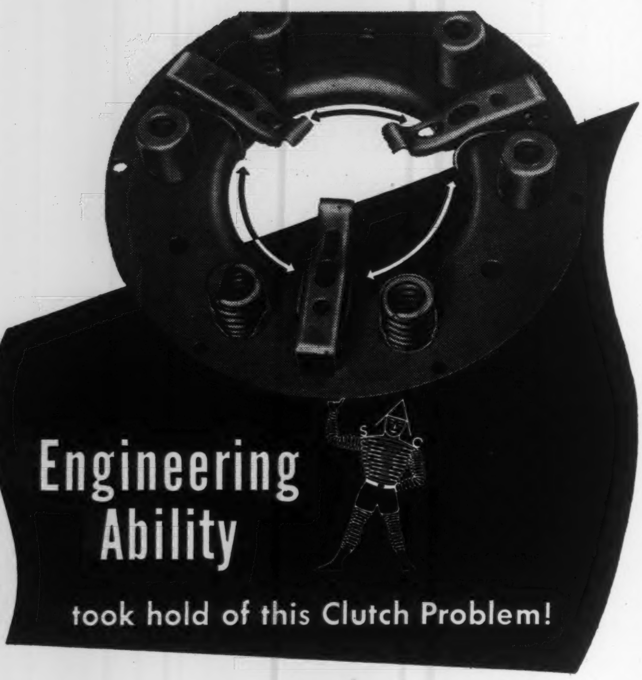


Mercury Automatic Clutches Have These Outstanding Features

Multi-Purpose • Completely Automatic • Lightweight Dependable • Positive Drive • Smooth Pick-Up • Positive Release • Inertia Delay • Dynamic Balance • Operate in Either Direction • Long Life • Overload Protection

3 Mercury Catalogs . . .

MERCURY CLUTCH DIVISION
AUTOMATIC STEEL PRODUCTS, INC.
CANTON 6, OHIO



...with Springs by
AUTOMATIC SPRING COILING COMPANY

This clutch manufacturer was having a problem.

The action of a lever in this particular type of clutch was such . . . that tension had to be applied in quite an unusual manner. And not only was there no standard spring to do the job . . . but also no known machine capable of turning out the necessary custom-built spring!

Then Automatic Spring Coiling Co. was called in . . . and we put *Engineering Ability* to work.

Our consulting engineers analyzed the situation . . . and designed a *special machine* to produce a special *spring* . . . which was also **Shot-peened* for fatigue strength, thereby adding immeasurably to its life potential.

Samples were made and put to repeated and conclusive tests. RESULT: More perfect clutch operation with guaranteed longer life and a considerably lessened chance for shock, slippage, vibration, grabbing and chattering.

Make it a point to consult Automatic Spring Coiling Company early in the job. Take advantage of our . . . ENGINEERING ABILITY . . . gleaned from 30 years of Precision mechanical spring specialization, and by strict adherence to Quality-Controlled standards.

**Incidentally,* "Shot-peened" *springs for added fatigue strength are among our specialties.*

Our veteran consulting engineers are ready to survey your requirements without obligation. Write us today for full details.

AUTOMATIC SPRING COILING CO.
4043 West Thorndale Avenue
CHICAGO 30, ILLINOIS

terminology and abbreviations, screw threads, gaging practices, fastener materials and manufacturing processes.

SAE Manual on Shot Peening. 45 *pages,* 8½ *by* 11 *inches, paper bound; available from Society of Automotive Engineers,* 29 *W.* 39*th St., New York* 18, *N. Y.;* $1.50 *for members,* $3.00 *for nonmembers.*

Prepared by the SAE Iron and Steel Technical Committee, this manual is intended as a practical aid to designers and engineers, pointing out both the possibilities and the limitations of the shot peening process. Covered in the manual are description of the process, types of shot peening machines, shot materials, effect of shot peening, production procedure, theory of strengthening metals by shot peening, and process specifications. A table of examples of current shot peening practice and a bibliography are also included.

Standards of Tubular Exchanger Manufacturers Association. *Third edition;* 162 *pages,* 8½ *by* 11 *inches, wire-ring binding with flexible cover; available from TEMA,* 53 *Park Place, New York* 7, *N. Y.,* $5.50 *postpaid.*

Revised from the 1949 volume, this new edition covers standard nomenclature; material specifications; thermal standards; maintenance suggestions; mechanical standards for Class A, C, and R heat exchangers; and general design information. The sections on Class A heat exchangers (alloy steel) and general design information are new and the other sections have been expanded to conform with recent findings and conclusions of the TEMA Technical Committee.

Government Publications

Federal and State Weights and Measures Laws. *National Bureau of Standards Circular* 501; 1182 *pages,* 8 *by* 10¼ *inches, imitation leather bound; available from Government Printing Office, Washington* 25, *D. C.;* $5.75 *postpaid.*

Superseding three earlier volumes published by NBS in 1904, 1912 and 1926, this compilation comprises an up-to-date collection of federal laws and regulations and state laws dealing with the regulatory control of commercial weighing and measuring equipment and practices.

Printed Circuit Techniques: An Adhesive Tape-Resistor System. *By B. L. Davis; National Bureau of Standards Circular* 530; 83 *pages,* 7¾ *by* 10¼ *inches, paper-bound, available from Government Printing Office, Washington* 25, *D. C.;* 30 *cents postpaid.*

This circular presents a complete description of development work on an adhesive tape-resistor which permits close control of resistance values. The work is part of a program sponsored by the Navy Bureau of Aeronautics and conducted by the National Bureau of Standards for the purpose of improving techniques for printing electronic circuits and subassemblies for airborne use. Included in the circular are a description of the carbon-resin film-type resistor developed, detailed information on production of the resistors and on equipment and materials needed, specifications and test methods, appendixes containing data on the carbons studied, and source of supply lists for all uncommon materials.

NACA Technical Series. *Each publication is 8 by 10½ inches, paperbound, side-stapled; copies available from National Advisory Committee for Aeronautics,* 1924 *F St. N. W., Washington* 25, *D. C.*

The following Technical Notes are available:

2671. **Investigation of Stress Distribution in Rectangular Plates with Longitudinal Stiffeners Under Axial Compression After Buckling**—61 pages

2679. **The Stability Under Longitudinal Compression of Flat Symmetric Corrugated-Core Sandwich Plates with Simply Supported Loaded Edges and Simply Supported or Clamped Unloaded Edges**—27 pages

2680. **A Compressible-Flow Plotting Device and Its Application to Cascade Flows**—21 pages

2701. **A Survey of the Aircraft-Noise Problem with Special Reference to Its Physical Aspects**—41 pages

2703. **Electrical Techniques for Compensation of Thermal Time Lag of Thermocouples and Resistance Thermometer Elements**—85 pages

2704. **Fatigue Strengths of 14S-T4 Aluminum Alloy Subjected to Biaxial Tensile Stresses**—24 pages

Additionally, the following Technical Memorandum is available:

1339. **Velocity of Action of Oxygen, Hydrogen Sulfide, and Halogens on Metals**—21 pages.

Manufacturers' Publications

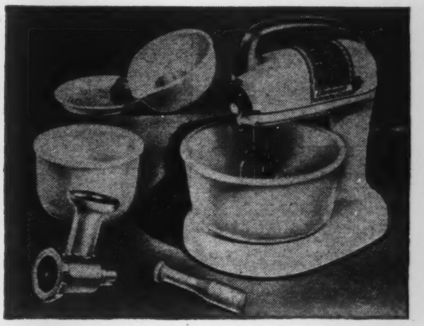
Modern Arc Welding. 544 *pages,* 5½ *by* 7¾ *inches, imitation leather bound; available from Hobart Trade School, Hobart Square, Troy, Ohio;* $3.00 *postpaid.*

Procedures and practices of arc welding are the subject of this rudimentary textbook which contains twenty-eight chapters divided into five main parts. Part 1 is introductory and covers general information—development, applications, materials, equipment and basic procedures of arc welding; Part 2 describes detailed techniques; Part 3 discusses carbon-arc welding and cutting; Part 4 deals with other arc-welding processes; and Part 5 is a glossary of standard welding terms.

North American Combustion Handbook. 340 *pages,* 6 *by* 9 *inches, clothbound; available from North American Manufacturing Co.,* 4455 *East* 71st *St., Cleveland* 5, *O.;* $2.00 *plus postage.*

A basic reference on industrial heating with liquid and gaseous fuels, this handbook covers theory of combustion; combustion, heat transfer and fluid flow calculations; and combustion equipment selection and operation.

KUX
FIRST NAME IN DIE CASTING MACHINES



used to produce DORMEYER
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Beats • Mixes • Grinds
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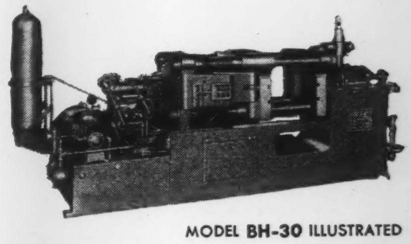
Write for illustrated catalog showing complete line of KUX Die Casting Machines.



MODEL BH-30 ILLUSTRATED
Hydraulically operated die casting machine for production of zinc castings weighing up to 10 pounds.

KUX MACHINE COMPANY
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Bearium Metal

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THE SUPERIOR BRONZE for Bearings, Bushings and Thrust Washers

JOB-TESTED by industry in hundreds of varying applications over a period of more than 20 years, records of performance prove that BEARIUM METAL greatly prolongs bearing life, prevents scoring and seizing of the shaft—*saves* many times its cost in reduced operating expenses and continuous trouble-free service.

The amazing properties of Bearium Metal are due to an exclusive process which evenly distributes *minute lubricating lead globules throughout the bronze matrix.*

ROUGH CAST BARS
INDIVIDUAL CASTINGS
MACHINED PARTS
CENTERLESS-GROUND RODS

YOUR INQUIRIES ARE INVITED

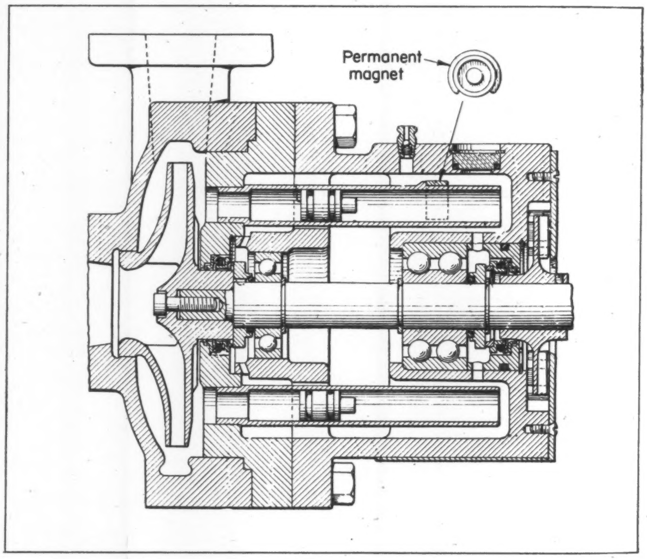
BEARIUM

LITERATURE AVAILABLE ON REQUEST

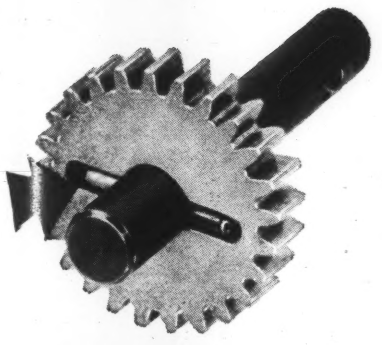
BEARIUM
METALS CORPORATION
266 State St. Rochester 14, N. Y.

NOTEWORTHY Patents

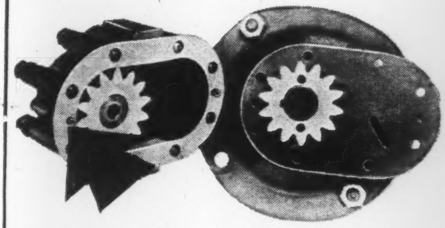
LIQUID SEALING of the impeller against leakage commonly encountered with ordinary packings is featured in a new centrifugal pump designed for volatile fluids. Equalizer pistons in open-end displacement cylinders or tubes having one end in communication with the discharge port and the other end in communication with the bearing chamber enable the pump to pressurize its own lubricant for sealing. The transmitted pressure is slightly greater than pumped liquid pressure at the shaft seal, thereby preventing ingress of the liquid and assuring lubrication of the seal faces. One of the tubes is made of nonmagnetic material and carries on its outer surface a C-shaped permanent magnet. The magnet moves in unison with the steel piston as it nears the end of its useful stroke and becomes visible through a bull's-eye in the bearing housing, thus indicating low oil supply. Patent 2,584,705 assigned to Ingersoll-Rand Co. by Hanns Hornschuch.



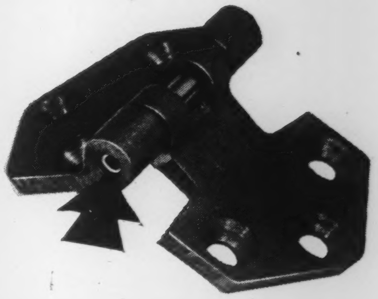
CONSTANT FILTRATION EFFICIENCY is obtained through the use of stainless steel helical springs as the filtering element in a vacuumized rotary-drum sludge remover. Individually, the springs are made up of tight-wound helical sections coupled internally by short studs. Between the studs is a filter core of resilient round material to prevent longitudinal flow or sludge packing inside the coils. To restrict flow between adjacent springs, outer surfaces of the coils are ground cylindrically to a uniform size. Traveling belt-fashion about an intake drum, which rotates partly submerged in a circulating tank, the spring elements lay in staggered relationship snugly



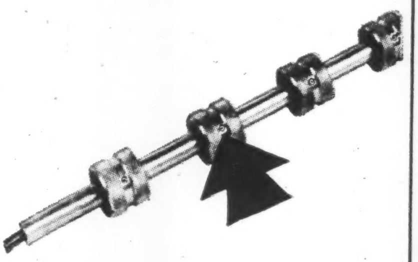
REPLACING A HUB ON A GEAR . . . Rollpin, self-retained in shaft, is simply snapped into molded slot to position sintered gear. This application, by Ditto Inc., effects major savings in assembly. Rollpin's high shear strength is particularly valuable here.



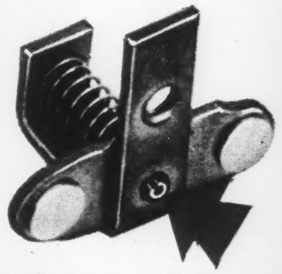
REPLACING A MACHINED PIN . . . In the lubrication pump assembly of the Cummins HR-400 diesel engine, two Rollpins are used as positioning dowels. Rollpins are self-retaining in production-drilled holes . . . quick to assemble and easy to remove.



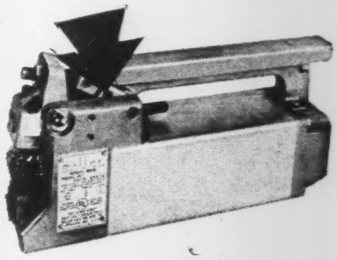
REPLACING A HEADED PIN . . . In this hinge pin application, Rollpin is simply and inexpensively driven in place, greatly reducing assembly costs. Constant spring tension holds Rollpin firmly in place . . . eliminates loosening of hinge due to wear.



REPLACING A SET SCREW . . . Paper feed rollers are quickly, economically pinned to shaft by Rollpins in this office machine made by Ditto Inc. Flush fit affords neat appearance . . . spring tension assures positive, permanent positioning of rollers.



REPLACING A RIVET . . . Rollpin serves as guide shaft for spring-loaded electrical interlock contacts. The Square D Company reports that rivet failure previously occurred at the clinched end under normal operating impact and vibration.



REPLACING A BOLT AND NUT . . . Rollpins act as fasteners and pivots for the linkages in this Miller Electric Welder. Rollpins may be used with a free fit in outer or inside members depending upon product design requirements.

6 more examples of assembly-time saving with ROLLPIN

TRADE MARK

Rollpins are slotted, tubular steel, pressed-fit pins with chamfered ends. They drive easily into holes drilled to normal tolerances, compressing as driven. Reaming, tapering, extra assembly steps are eliminated. Rollpins are *locked* in place by the constant pressure they exert against hole walls. Inserted with an automatic press or by hand, Rollpins are readily removable with a drift or pin punch—and reusable again and again.

Elastic Stop Nuts with the famous red collar are another ESNA® product

FOR DESIGN INFORMATION—fill out and mail our coupon. If your plans include applications similar to those on this page—or clevis pins, keys, taper pins or stop pins—you can't afford to be without details on how much faster and cheaper Rollpin can do the job.

Dept. R6-104, Elastic Stop Nut Corporation of America
2330 Vauxhall Road, Union, New Jersey
Please send me the following free information on ESNA self-locking fasteners:

☐ Rollpin bulletin and sample Rollpins ☐ AN-ESNA conversion chart
☐ Elastic Stop Nut Bulletin ☐ Here is a drawing of our product. What fastener do you recommend?

Name__________ Title__________
Firm__________
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City__________ Zone_____ State_____

STABILITY
IN EXTREME COLD
IN EXTREME HEAT
EXTRUDED
DIE-CUT
FIBERGLASS IMPREGNATED
MOLDED
SPONGE
Silicone rubber parts

SUCCESSFUL PERFORMANCE where other materials fail is the record of Arrowhead's many new ArcoSil silicone rubber products.

New silicone compounds and new fabrication techniques developed at Arrowhead now make possible the design of parts which retain flexibility and give long service at extreme temperatures ranging from −125° F. to as high as 700° F. Silicone rubber parts with greater resistance to abrasion and permanent compression set, with ideal dielectric properties and excellent resistance to many oils and chemicals, are constantly being produced to meet unusually severe conditions.

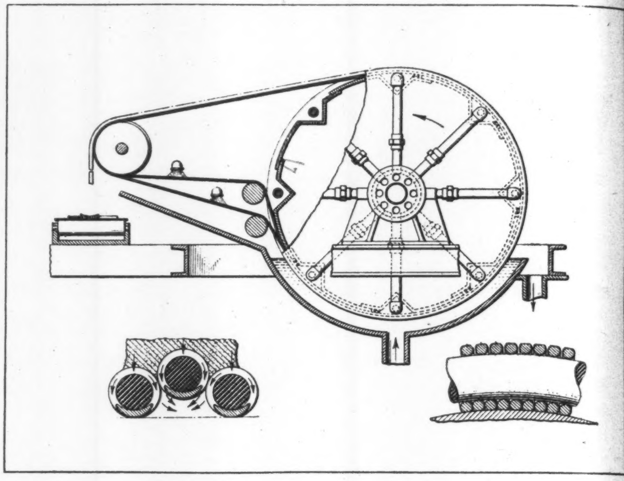
For a solution to difficult design problems investigate the new abilities of ArcoSil Silicone Rubber parts. Arrowhead sales engineers are available in all industrial areas to provide information and engineering assistance.

Write for new bulletins and name of nearest Arrowhead representative. Dept. C-70.

Foremost Fabricators of MOLDED PARTS of complex shapes and/or bonded to metal; EXTRUDED SHAPES of all kinds; SPONGE RUBBER extrusions and sheets; DIE CUT gaskets; RUBBER IMPREGNATED fiberglass.

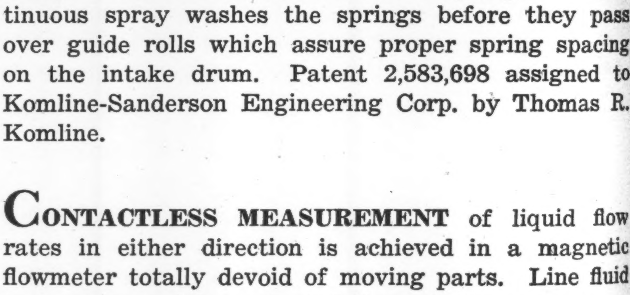
"O" RINGS
AIRTRON DUCTS
ARCOSIL SILICONE RUBBER PRODUCTS

ARROWHEAD RUBBER COMPANY
Division of National Motor Bearing Company, Inc.
DOWNEY, CALIFORNIA (Los Angeles County)
FIRST commercial manufacturers of precision "O" rings; PIONEER fabricators of silicone rubber; ORIGINATORS of rubber-fiberglass ducting.

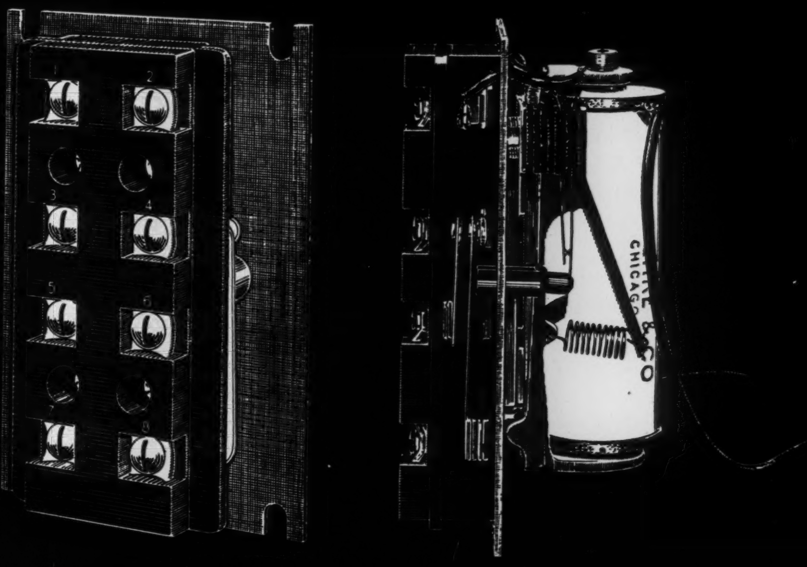


between retaining flanges on the drum. Transverse channels in the periphery of the drum are vacuumized from an outside source through a ported collector gland only while submerged or covered by the springs. Fluid suspended particles unable to pass between the flexed coils are arrested cumulatively on the springs and are "de-watered" after emerging from the reservoir. Passing over a second drum, smaller than the intake drum, greater flexure of the coils loosens the sludge which then drops from the springs. A continuous spray washes the springs before they pass over guide rolls which assure proper spring spacing on the intake drum. Patent 2,583,698 assigned to Komline-Sanderson Engineering Corp. by Thomas R. Komline.

CONTACTLESS MEASUREMENT of liquid flow rates in either direction is achieved in a magnetic flowmeter totally devoid of moving parts. Line fluid to be measured is conducted through the meter in an annular channel surrounding a soft iron core member. Outer wall of this channel, which is nonmagnetic, is encircled by a wound primary coil mounted axially between two secondary or pickup coils series-connected with a galvanometer. When the primary coil is energized with high-frequency current and the fluid is static, the pickup coil circuit is balanced to produce a zero meter indication. Flow in either direction through the channel produces asymmetrical voltages in the pickup coils proportional to the rate of flow. Pickup voltage difference registered on the



Bring your relay problems to CLARE



Front View

Side View

CLARE Type "CP" POWER RELAY

● Some of the most important relay developments of the past decade have been the result of CLARE cooperation with engineering staffs of acknowledged leaders in the electrical and electronic industries.

Development of the CLARE Type CP Power Relay, for instance, came about from a consultation with a large electrical manufacturer who uses power relays extensively in the manufacture of various electronic control units. This CLARE customer objected to the use of ordinary power relays in plate circuit applications because one watt or more was required to operate them. Also, this necessitated the use of a high-current thyratron tube, or the interposition of another, more sensitive relay. He wanted a power relay sensitive enough to operate in the plate circuit of any triode, including miniatures.

Years of satisfactory service from CLARE telephone-type relays had convinced the customer's engineers that the best way to achieve this would be to adapt these sensitive, dependable, durable relays to suit the special requirements of their use as power relays. Valuable contributions to the design of the CLARE Type CP Power Relay were made by the customer's engineers.

The result of this cooperation between these engineers and the CLARE engineering staff is a relay which simplified control equipment, saves money and space, and will outwear several ordinary power relays.

CLARE engineers, both in the field and in the plant, are anxious and willing to cooperate with you and your engineers to solve perplexing relay problems. Call the nearest CLARE office or write: C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. In Canada: Canadian Line Materials Ltd., Toronto 13. Cable Address: CLARELAY.

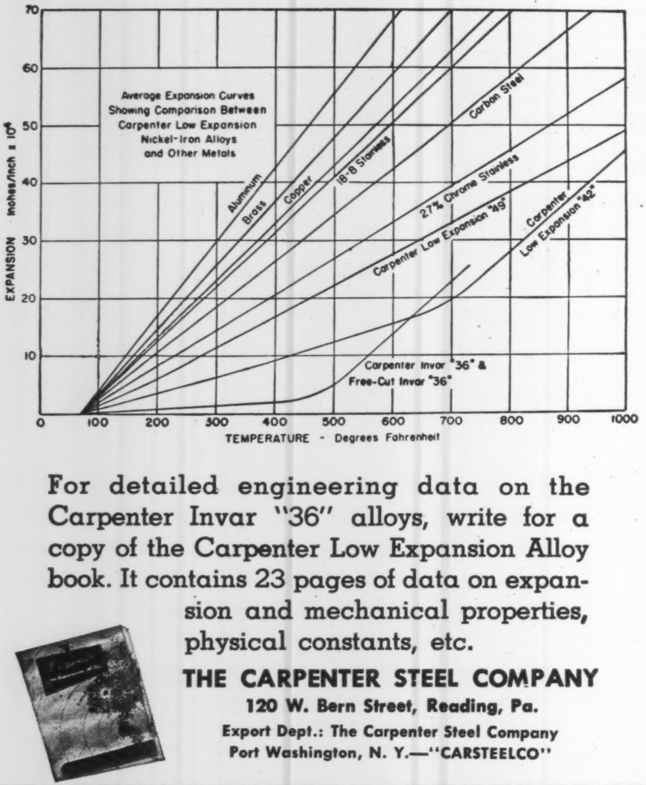
CLARE RELAYS

First in the Industrial Field

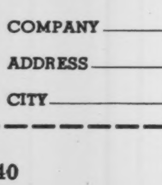
An alloy with practically no thermal expansion up to 400°F

Note in the graph how the low thermal expansion rate of Carpenter Invar "36" compares with other metals. The free-machining alloy, Carpenter Free-Cut Invar "36", has the same low expansion characteristics and simplifies production of machined parts.

Where the operation of precision instruments or machines is affected by temperature variations, the low expansion of this alloy helps to insure constant accuracy. Another important use is in automatic on-and-off controls, such as thermostats. These controls are operated by the difference between invar's low expansion rate and that of a high expansion metal.



For detailed engineering data on the Carpenter Invar "36" alloys, write for a copy of the Carpenter Low Expansion Alloy book. It contains 23 pages of data on expansion and mechanical properties, physical constants, etc.



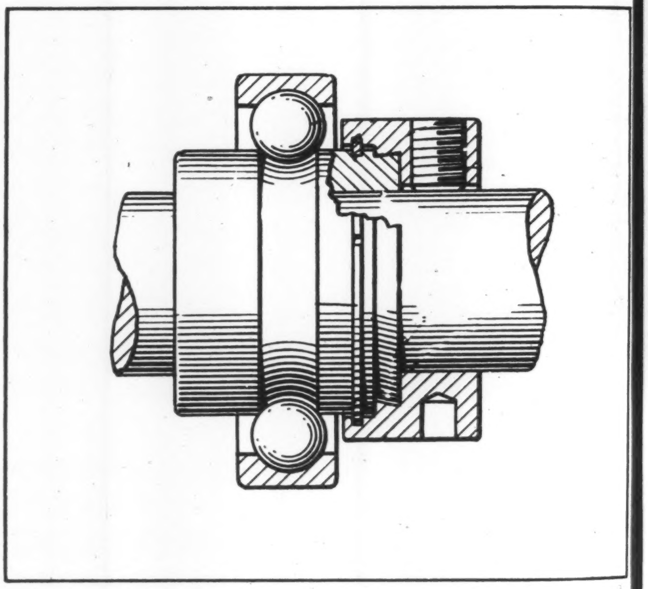
THE CARPENTER STEEL COMPANY
120 W. Bern Street, Reading, Pa.
Export Dept.: The Carpenter Steel Company
Port Washington, N. Y.—"CARSTEELCO"

THE CARPENTER STEEL CO., 120 W. Bern St., Reading, Pa.
Please send a copy of your Low Expansion Alloy Book.

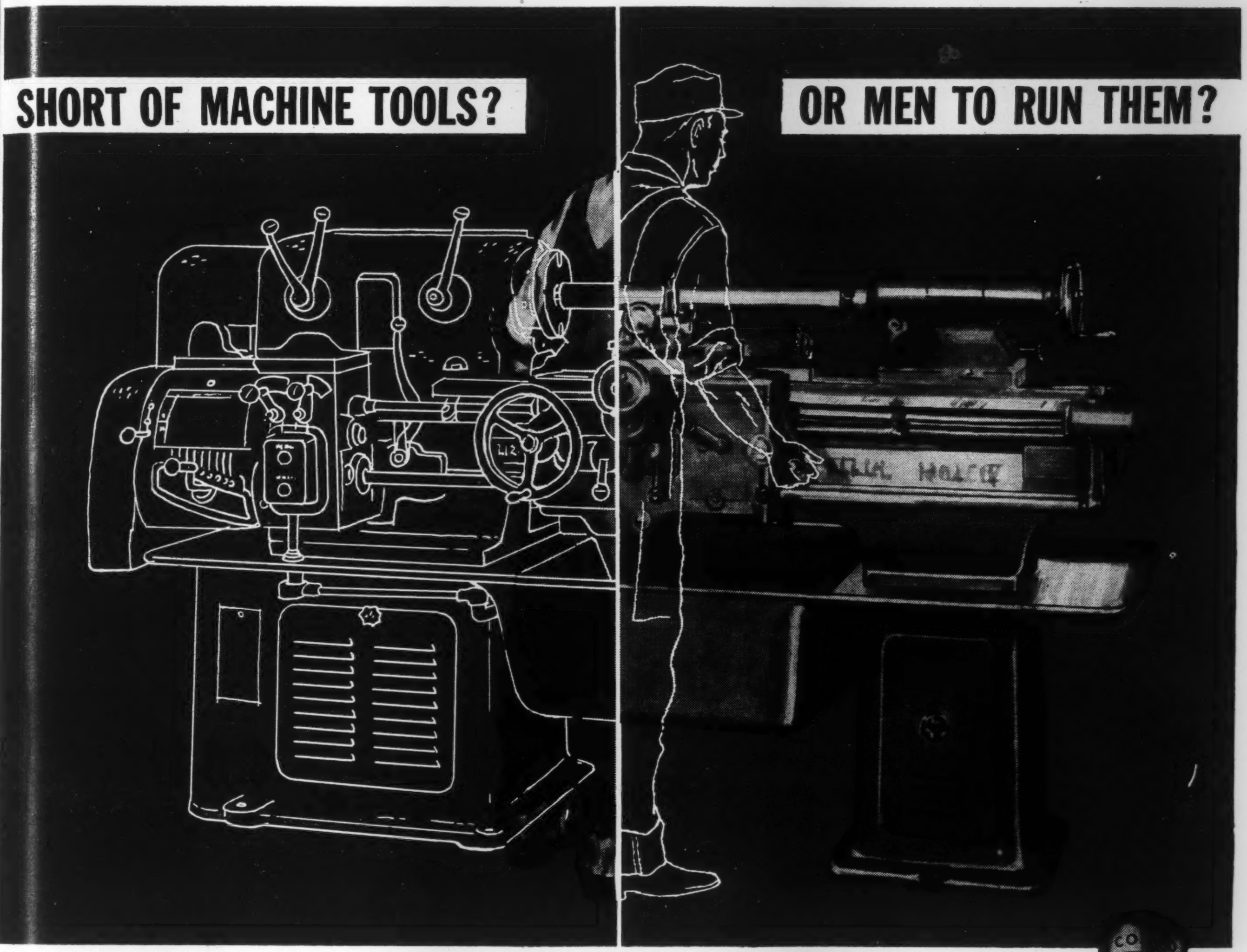
NAME ______ TITLE ______
(Please Print)
COMPANY ______
ADDRESS ______
CITY ______ ZONE ______ STATE ______

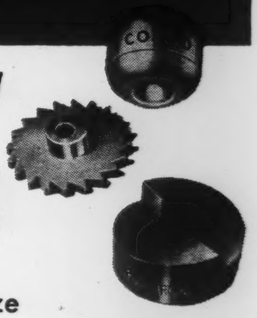
galvanometer, therefore, constitutes an indication of flow rate and direction according to cross-sectional area of the channel. To shield the magnetic circuit from the influence of extraneous magnetic fields, an outer housing of high magnetic permeability is provided. Patent 2,583,724 assigned to Socony-Vacuum Oil Co. Inc. by Robert A. Broding.

SELF-TIGHTENING of a ball bearing on its shaft through the inner race's natural tendency to creep is provided by an eccentrically bored setscrew collar attached to the race. Held laterally to the collar by a rectangular-section snap ring, the bearing race has an extending external eccentric surface, corresponding to that inside the collar, designed to resist separation under load. This construction permits the convenience of a sliding fit in initial assemblies. In addition, it provides quick locking with anticreep assurance and ready unlocking for servicing on future occasions without distortion or damage to the bearing race. Patent 2,584,740 assigned to the Fafnir Bearing Co. by Harry R. Reynolds.



KNIFE-EDGED LINKAGE increases the speed sensitivity of a spring-balanced centrifugal governor by eliminating undesirable friction in the balance mechanism. In addition to their normal function, the balance weights center the free end of the spring assembly through rolling friction engagement of contoured ends with the spring adapter. A sleeve extension of the adapter is piloted in the spring adjusting nut to stabilize the assembly. Tendency of the adapter to rotate as the spring alternately compresses and extends is cancelled by a ball thrust bearing under the spring. A self-aligning ball bearing as-


SHORT OF MACHINE TOOLS?
OR MEN TO RUN THEM?



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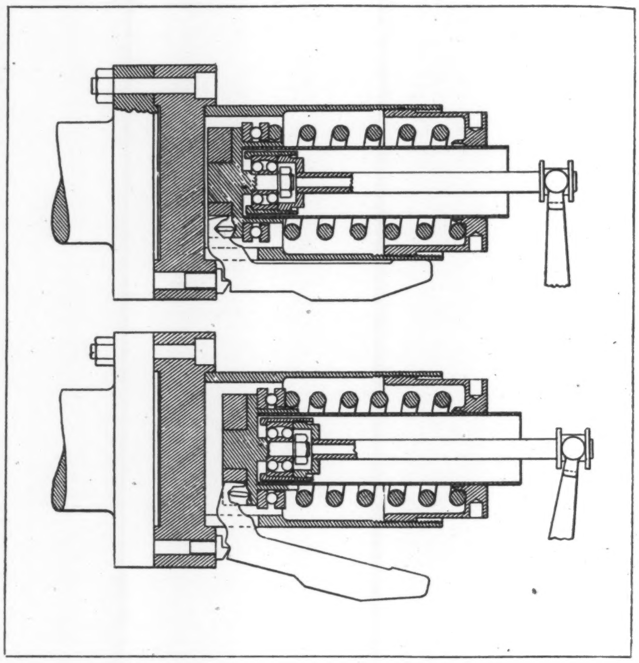
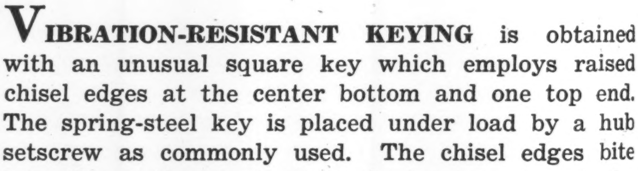
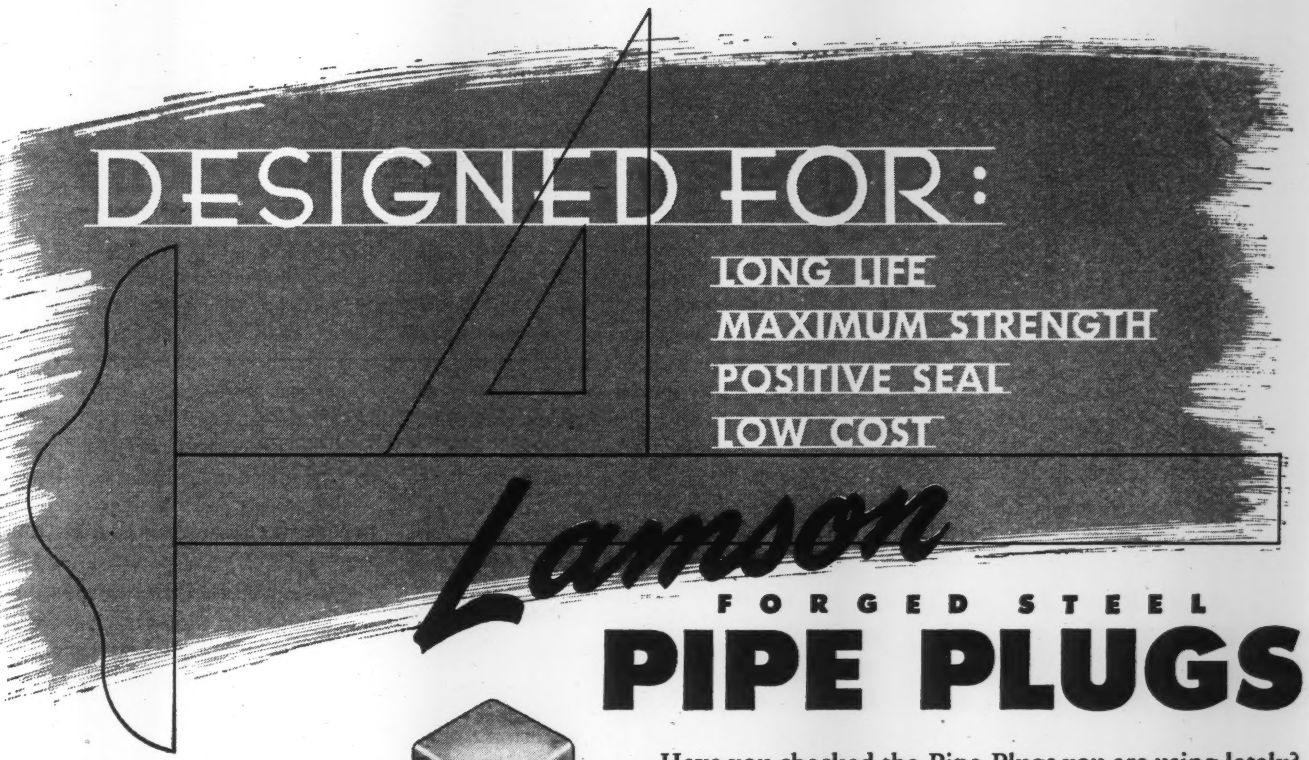


sembly which couples the takeoff control rod to the adapter prevents binding action at this point. Patent 2,580,556 assigned to Allis-Chalmers Mfg. Co. by Edward M. Kuemmerlein.

VIBRATION-RESISTANT KEYING is obtained with an unusual square key which employs raised chisel edges at the center bottom and one top end. The spring-steel key is placed under load by a hub setscrew as commonly used. The chisel edges bite into the mating parts to resist movement and the spring effect counteracts loosening from wear. Patent 2,588,064 assigned to the Iron Fireman Mfg. Co. by Ernest C. Webb.





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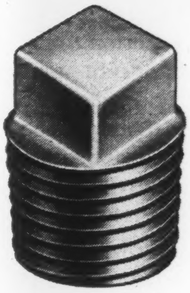

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So next time specify Lamson Pipe Plugs—in steel, brass, bronze or aluminum—and give your product the extra advantage it deserves.

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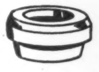
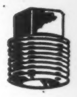


PLUG NUTS
A tapped insert for fast, positive and efficient assembly. Reduces fastening costs.



PIPE PLUGS
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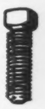

"1035" SET SCREWS
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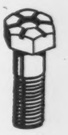

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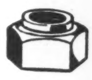

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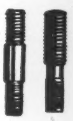

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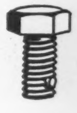
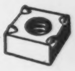


DIAMOND LOCK SCREWS
Plastic insert locks threads. Can be reused.



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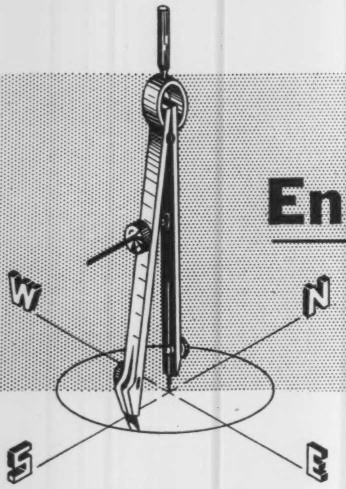


Engineering News Roundup

Heavy Presses Step Up Aircraft Output

Construction of 17 heavy presses—eight extrusion and nine forging—ranging from 8,000 to 50,000 tons capacity has begun over the past year at various points in the United States. The newest of these is the press at Bohn Aluminum and Brass Co., Adrian, Mich., which has just started production. Two others, at the Aluminum Company of America plant in Cleveland and the Wyman-Gordon plant in North Grafton, Mass., are already in production.

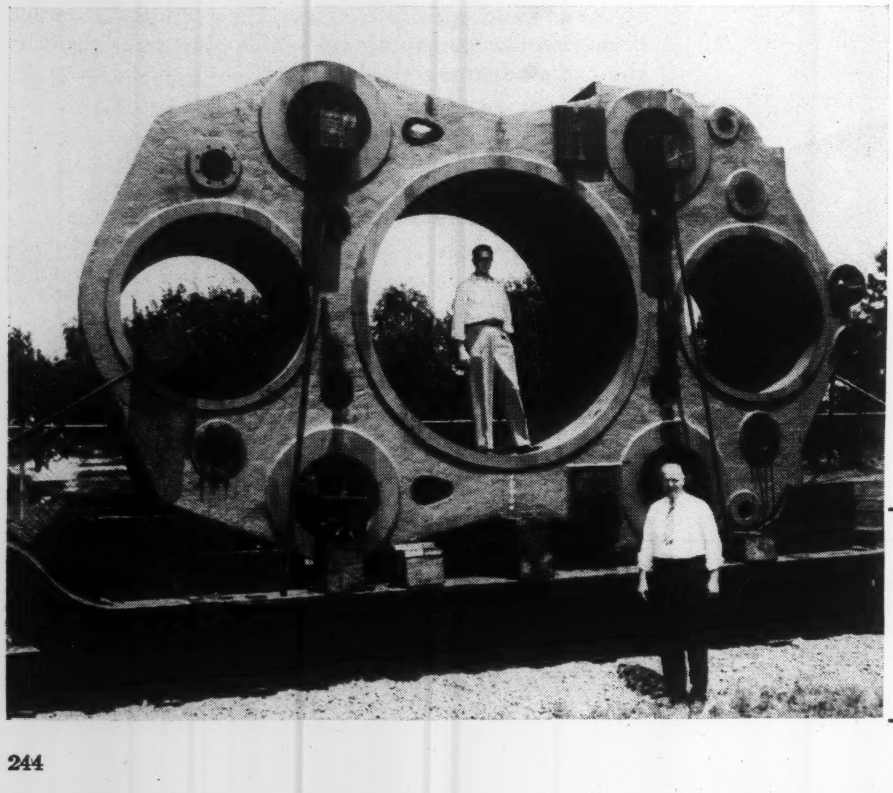
Within the next few years, according to the Air Force, these giant presses will be turning out large aircraft and engine parts in a fraction of the time required by present production methods. By stamping out whole sections, instead of the present "bits and pieces" assembly method used for wing sections, ribs and frames, the forging presses will make possible unique new designs, involving savings both in time and money.

Of the three presses now in production, the Wyman-Gordon press is the only one of American construction—the other two having been brought from Germany. The Wyman-Gordon press is of 18,000 tons capacity, and the two German presses are each of 16,500 tons capacity.

Presently, the major problem in full utilization of the new presses is the time necessary to complete a set of airplane dies. Existing die-block capacity in the United States is estimated at from 40,000 to 50,000 tons annually, mostly capable of producing only smaller size blocks. When the heavy press program is operating at an efficient level, the Air Force estimates that annual die-block requirements for this purpose alone may well run from 50,000 to 75,000 tons, and these blocks may average over 20 tons each.

One of the important assets of the heavy press is that it is readily adaptable to the handling of new shapes. While the basic structure of an airplane usually does not change through as many as a dozen model changes, in the case of an entirely new design new die-blocks could be used on the same press, and the same handling equipment would be utilized. Both the forging and extrusion presses will have some advantages in working magnesium and the newer high-strength aluminum alloys.

Forging presses still to be scheduled range up to 50,000 tons capacity, and extrusion presses have been contracted for up to 20,000 tons capacity.



Giant 107-ton casting will be the cylinder housing for one of the largest extrusion presses in the United States, to be installed at Alcoa's Lafayette works

Passenger Conveyor Tested for Subway

An experimental passenger conveyor belt that ultimately may be part of a subway system for carrying passengers is currently being tested by Goodyear Tire & Rubber Co. Proposed by Goodyear and Stephens-Adamson Mfg. Co. as a substitute for the present Grand Central-Times Square shuttle train in New York, the new system would use moving loading and unloading platforms and small, closely spaced passenger cars riding on an endless track of rubber conveyor belts and rubber-tired banks of accelerator wheels.

An experimental loading platform has been tested by Goodyear and has passed all its tests satisfactorily after a year of continuous experimentation. This passenger conveyor belt is 68 feet long, increased to 85 feet by entrance and exit ways. The belt itself is 24 inches wide and is driven by a 3-horsepower electric motor geared to provide speeds from less than one mph to 5 mph.

Experiments with the passenger conveyor included tests with women wearing all types of shoes from French-heeled pumps to sandals. In some instances the "human guinea pigs" were given packages to carry, hampering both arms. Tests were run using small children, with and without adult guidance, either walking on the moving belt by themselves or being carried on in the arms of an adult. From the tests, a speed of 1½ mph was determined as the safest operating speed for a single belt in a system on which persons are required to enter by walking.

The experimental passenger belt test installation simulates the requirements of the actual system proposed for the New York shuttle, even to a moving handrail synchronized with the speed of the belt. In the proposed shuttle system, the passenger conveyors would act as loading platforms for loading and unloading passengers into the moving passenger cars. These platforms would be moving belts 6 feet wide. This same system has also been proposed as a moving sidewalk. Alongside the loading belt, and moving at the same speed, would be a continuous stream of small passenger cars with seats. Twenty-five cars, each seating ten persons, would pass the loading platform every minute. After leaving the loading platform, the cars would be speeded up to 15 mph over banks of accelerated wheels and then would be carried by the main conveyor belt. At the other end the cars would be slowed by a similar system before moving onto a belt moving at unloading platform speed. Empty cars would be turned around by a large wheel and would then be moved alongside the loading platform going in the opposite direction.

Experimental passenger conveyor tested by Goodyear for over a year

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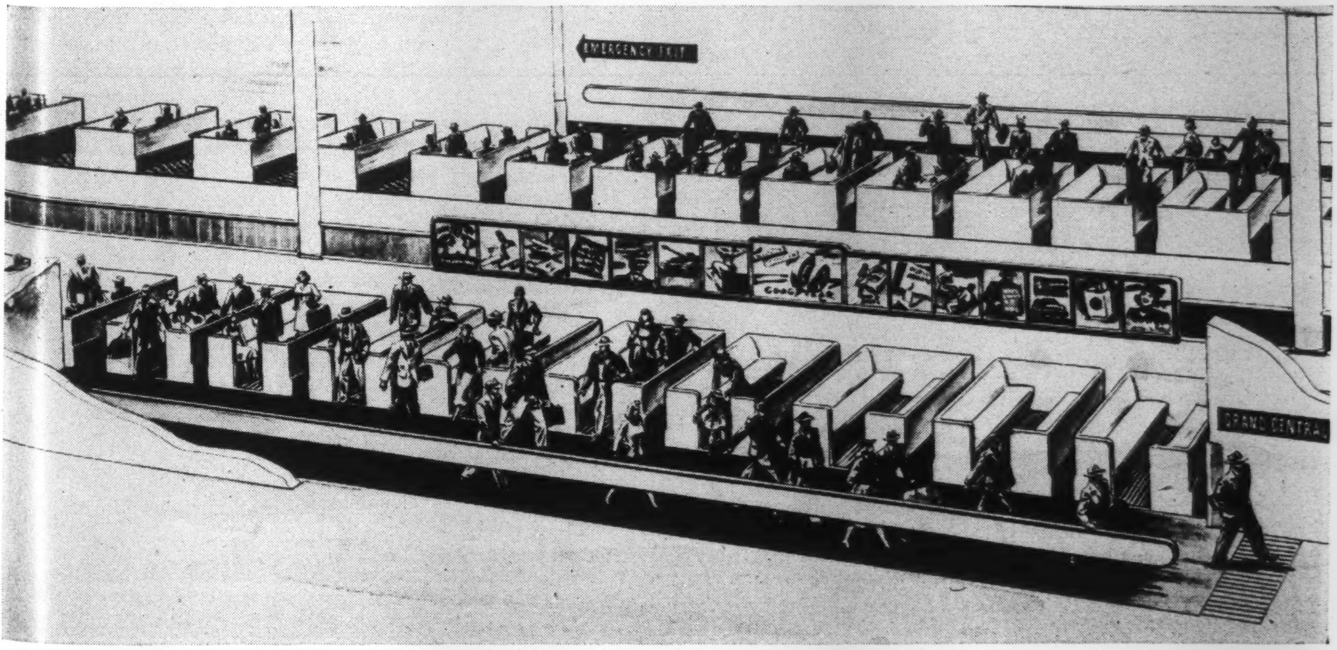
Proposed loading and unloading platforms for the Grand Central-Times Square subway conveyor belt

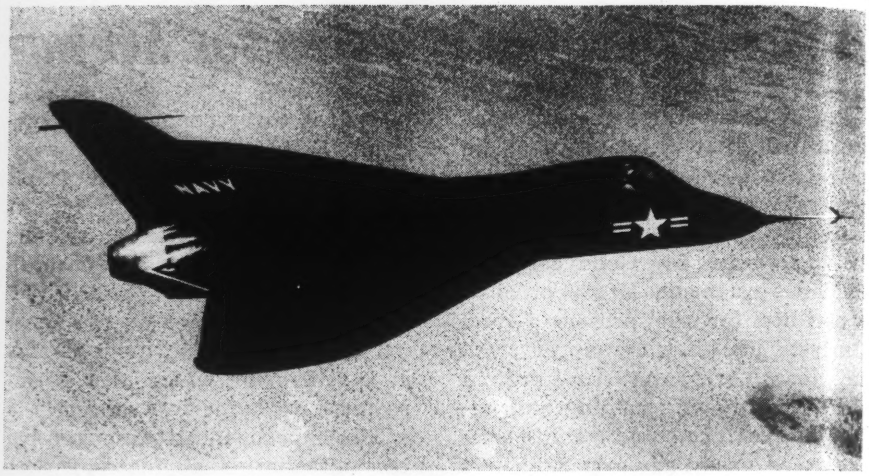


400 Firms to Exhibit At National Metal Congress

Over 400 nationally known firms concerned with metal working in its many phases will display and demonstrate their products over nearly 5 acres of floor space at the National Metal Exposition, October 20 to 24. Sponsored by the American Society for Metals, the 34th Metal Show will cofeature exhibits at the Convention Halls, in Philadelphia, Pa., and technical meetings which will take place from October 18 to 24.

Bringing together the experience, knowledge and means for a more effective use of metals, the Metal Show will feature the theme "Metal Keeps The Peace." Emphasis will be on the use of metals in making products that will insure our defense against aggression, and in the manufacture of products for civilian use.

In addition to the technical sessions devoted to metallurgy in its many phases, the practical production of metal products will be covered in the technical sessions. Thus, the American Welding Society, in addition to papers on welding processes plans several papers on the welding of the newer alloys such as titanium and magnesium. Similarly, a symposium on titanium and titanium alloys is planned by the American Institute of Mining and Metallurgical Engineers.



First air photo of the F4D Skyray, the Navy's newest jet interceptor

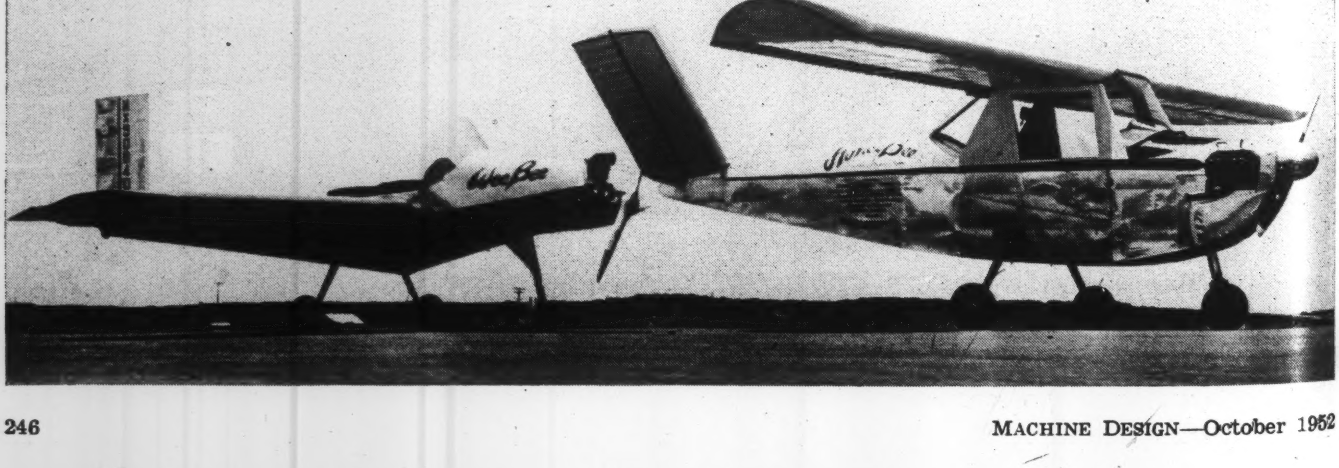
Honey Bee and Skyray—Two New Aircraft Designs

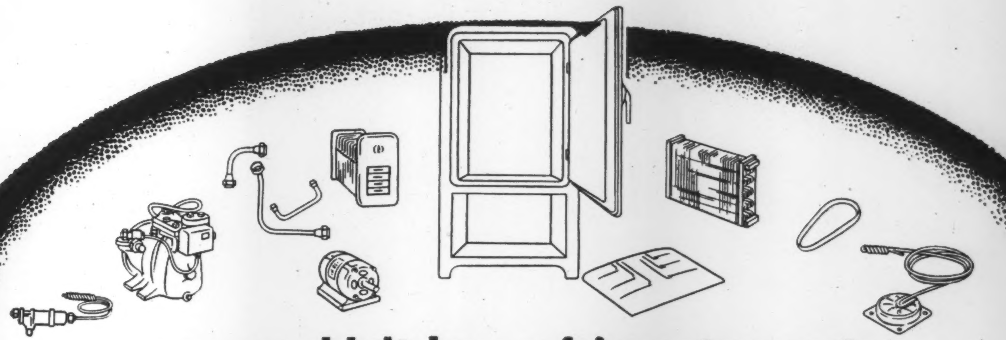
Sharp differentiation in aircraft design is shown between the Douglas F4D Skyray interceptor and the Honey Bee developed by Beecraft Associates Inc. The first air photo of the Navy's jet interceptor, which is designed for operation from a carrier, shows clearly the thin planform or "delta" type wing. Designed to climb rapidly to high altitudes, the Skyray is built around a huge, late-model jet engine. It was named from its resemblance to the ocean-dwelling manta ray, and is now undergoing flight testing for the Navy.

The Honey Bee, which is called the "world's sweetest plane" by its designers, is a single-place airplane that weighs only 550 pounds and has a wing span of 28 feet. Capable of a 120-mph top speed and a cruising speed of 110 mph, the plane has an all-metal stressed skin and spring-steel tricycle landing gear. The high-wing monoplane is equipped with a 65-hp engine. Hydraulic brakes are installed in the main gear, and the nose wheel ca be steered from the rudder pedals.

Beecraft associates are also designers of the Wee Bee, called the "world's smallest plane". The Wee Bee, which made demonstration flights about two years ago, is piloted from a prone position. It is big enough to lift a man, yet is small enough to be lifted by one.

The Wee Bee and Honey Bee, two recently developed single-place small planes





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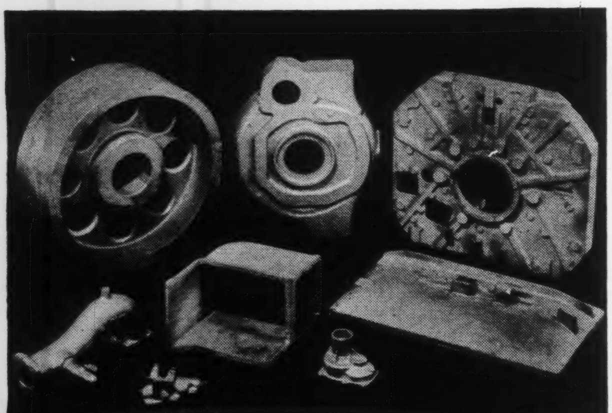


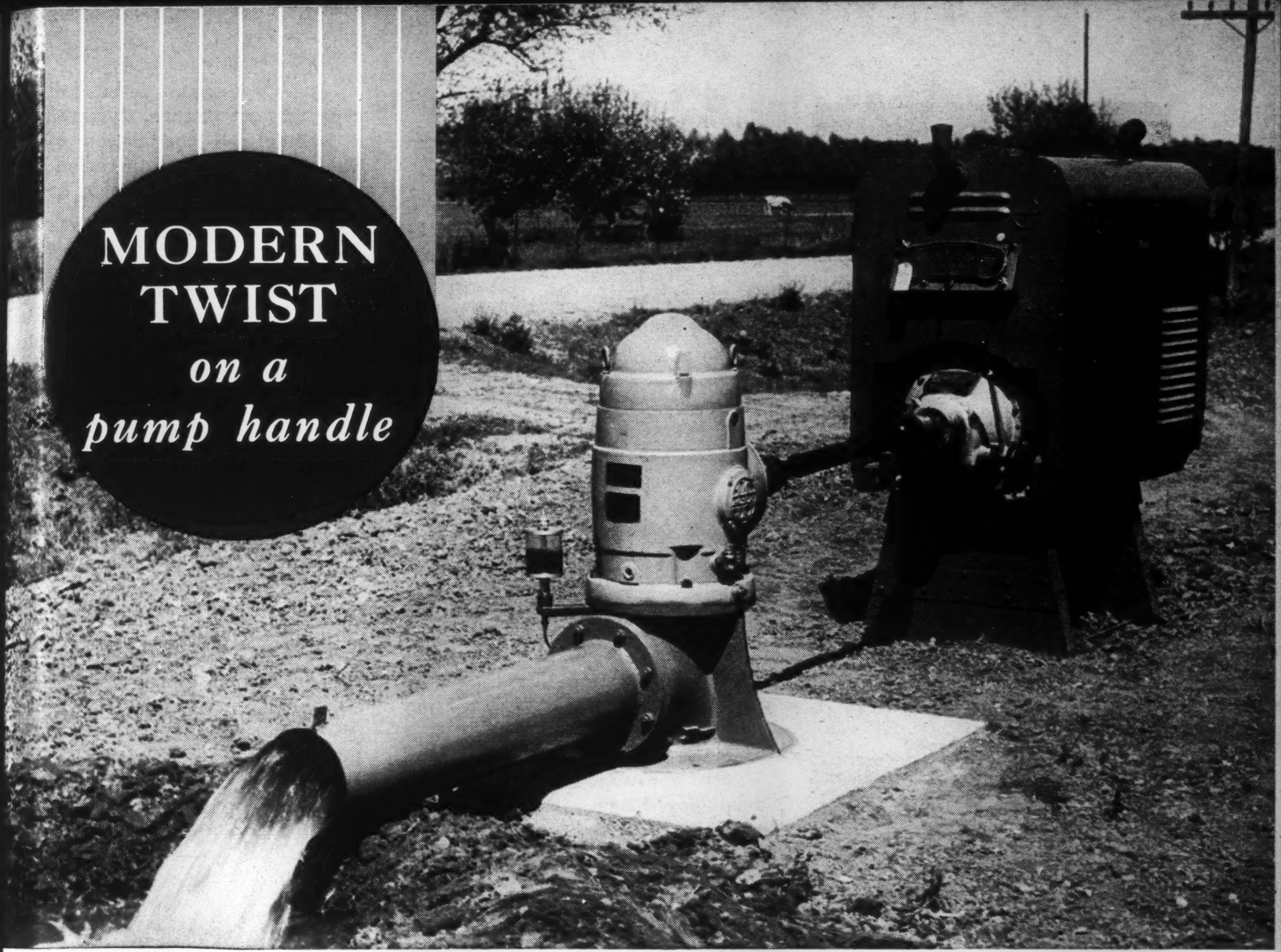
New Man-Made Fiber Blown from Bubbles

A new manmade fiber, which resists temperatures that melt cast iron yet is so fine that it can be used as a superfilter, has been manufactured from aluminum oxide and sand by the Carborundum Co. Generally expected to find a quick use in insulation and fireproofing, the new material will not only resist fire and prevent heat loss, but will also deaden sound and provide a filtering medium.

Research engineers came upon the material during their early work on alumina "bubbles" which are extensively used as insulation in high-temperature commercial applications. The bubbles are made by blasting molten alumina with air. During this operation, it was noted that occasionally fibers were formed. By working with alumina and silica, developing modifying agents, and by extensive experimentation with temperatures and air-blast pressures, researchers were able to carry the blowing process beyond the bubble stage, and in effect blew each bubble into a fine fiber.

Aluminum oxide and sand are melted in an electric furnace, and a molten stream of the lava-like material is subjected to a controlled blast of air. The material is thus blown into a fluffy mass of

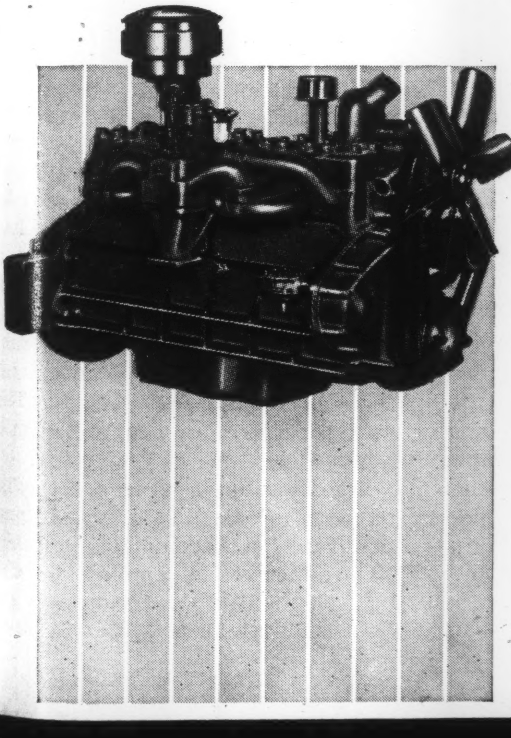
When solid aluminum silicate, right, is melted and subjected to a blast of air, a fluffy mass of cotton-like "Fiberfrax" fiber, left, is produced



MODERN TWIST *on a pump handle*

Photo—Courtesy Western Land Roller Co., Hastings, Nebraska

discharges 1050 gallons of water a minute from 100 feet down!



This 8-inch Deep Well Turbine Pump is furnishing water for irrigation purposes near Hastings, Nebraska. It is powered by a Model 8-A Chrysler Industrial Engine with right angle gear drive.

This is Chrysler high speed and Chrysler high compression doing a specialized job. Other farming, construction, industrial and specialized applications are no exception to this kind of regular performance. Here are a few of the advantages you get in Chrysler Industrial Engines: superfinished wear surfaces, sodium cooled exhaust valves, updraft or downdraft carburetion—and there are many more tailored to the exact needs of your job.

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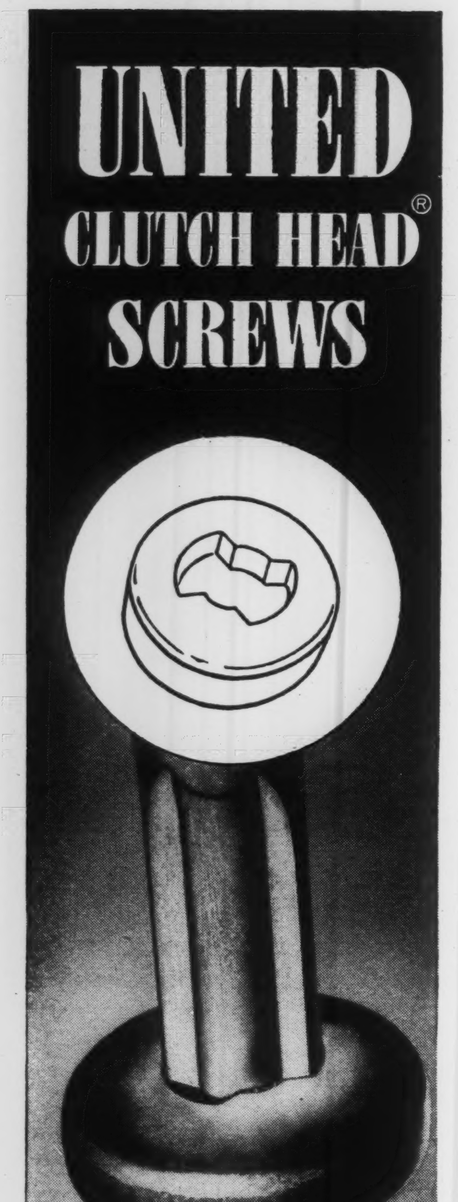

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random arrangements of extremely fine fibers, ranging from 1 to 3 inches in length and with a thickness of about 1/25 that of a human hair.

Melting of the alumina and silica is done at 3300 F. "Fiberfrax," as the new material is known, easily withstands 2300 F without loss of properties and does not soften at temperatures approaching 3000 F. Since its raw materials are relatively inert, the resulting fibrous mass is corrosion-resistant. The random arrangement of fibers produces efficient filtering and also accounts for the pronounced capillary characteristics of the Fiberfrax fiber.

Basically the product is a vitreous ceramic, rather than crystalline. Relatively rapid cooling from the melt provides the fibers with a smooth vitreous surface and long length, and may account for their resiliency. Chemical data are still being evaluated, but preliminary tests indicate that the material's inert components and very low alkali content make it highly resistant to acid attack. Although work up to now has concentrated on the high-temperature possibilities of the material, "cold" applications exist in which the fiber can compete with asbestos to provide strong, lightweight materials for thermal and electrical service.

Pulse-Jet Engine Has 200-hour Operating Life

A pulse-jet engine, of the type used in the so-called "flying stovepipe" of World War II but with an operating life of 200 hours instead of 40 minutes, has been developed. The new engine announced by the Naval Research Laboratory is expected to find military use primarily in subsonic, expendable flying craft, such as guided missiles. Because the operating life of 200 hours compares favorably with the normal flight time before overhaul of conventional reciprocating aircraft engines, and because the engine is light, simple and easy to construct, it is also expected to be used as an engine for helicopter rotors.

The engine is a relatively new type, without pistons, flywheels, or a well-defined combustion space. The theory of its operation has not been fully determined, and it is not practical, therefore, to predict all of its potential uses or ultimate capabilities.

Generally, the engine consists merely of a cylindrical sheet-metal combustion chamber and tailpipe connected by conical sections. At the forward end a series of vanes or valves control admission of air to the combustion chamber. In operation, the air is mixed with fuel which is ignited in the chamber. A rapid increase of pressure results, closing the valves and forcing the hot gases out through the tailpipe to produce a high-velocity jet. During this expansion process, pressure in the combustion chamber drops below outside pressure and the valves are reopened, admitting a fresh charge. Once begun, this operation is self-sustaining, a spark being required only for the initial explosion.

This type of engine produces a static thrust several times as great as its own weight, and is not critical as to fuel quality. It requires no lubrication or cooling system. The final design evolved for the vane or valve system operates at a frequency of about 165 cps. In test a 6-inch diameter engine has operated for 200 hours on a whirling-arm test stand. During the test the engine ran at approximately 150 mph and was subjected to an average centrifugal force of approximately 114g. The valve operated for nearly 120 million cycles.

Two design features are credited with accounting for the long life. First, a thermoplastic rubber-like adhesive is applied to the striking edges of the vane. Second, the vane bars are rigidly secured in the side-plate slot to eliminate variations set up by the tremendous centrifugal force. Wherever possible, parts were designed light and flexible to deflect under the explosion force from the combustion chamber, and thus absorb energy. This design procedure has made possible the use of "ordinary" construction materials instead of the more expensive and scarcer alloys normally required for parts subjected to high impact and fatigue stresses.

New Laboratory to Study High-Velocity Structures

Research and study on structural problems in high-velocity aircraft such as rockets and supersonic aircraft will be centralized at Columbia University's new Engineering Center. The projected Aeronautical Structures Laboratory will conduct research, train graduates in a new field, and provide a clearing house for research information on aeronautical structures.

In announcing the laboratory, Dr. John R. Dunning, dean of the university's engineering school, pointed out that there is an urgent demand for specialists in such fields. In view of the growing emphasis by the aircraft industry on new, faster methods of propulsion, supersonic flight stability, and guidance control systems, the need has also arisen for the basic study of structures which can withstand the greatly accelerated speeds and high stresses that supersonic aircraft develop. In addition to investigating this problem, the new laboratory will also study structural problems stemming from such techniques as refueling while airborne, the use of "parasite" aircraft, and the carrying of radioactive material or equipment. One of the most important contributions of the laboratory project is expected to be a sharp reduction in the time lag between the development of new aircraft construction techniques and their application by designers.

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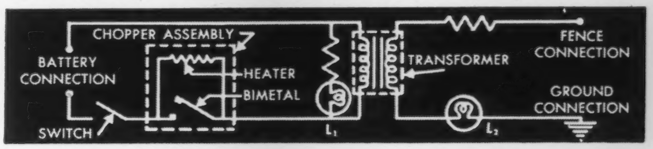
IN International's "FENCER"

The International Electric Fencer Model No. 106 keeps livestock under control by supplying an intermittent electrical charge to the fence line. This is especially advantageous to farmers in protecting crops and maintaining barn control. The device known as the "chopper" contains the bimetal actuating element and is rated at 3.4 million interruptions or 2000 hours of continuous operation. The reliability of the Fencer is largely dependent upon the actuating element of Chace Thermostatic Bimetal.



The chopper assembly consists of a straight bimetal element with contact in parallel with a resistance wire heater wound around the bimetal. Normally, the contacts are open so that initial current flows through the heater to cause the bimetal temperature to increase and move to close the contacts. This closing action shorts out the heater and decreases the temperature in the bimetal which then returns to its original open position. The current again passes through the heater to start the next operation cycle. A green light flashes during normal operation; and a red light flashes whenever the fence is grounded or the controller is shorted.

If the actuating element for your new control device is thermostatic bimetal, Chace is equipped to fabricate it ready for assembly. Our 29 types of bimetal are available in strips, coils, random long lengths and welded or brazed sub-assemblies. We invite you to consult with our Application Engineers, recognized authorities on temperature responsive devices — or write for our new 32-page booklet, "Successful Applications of Chace Themostatic Bimetal," containing condensed engineering data.

IT BENDS WITH THE HEAT

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Thermostatic Bimetal
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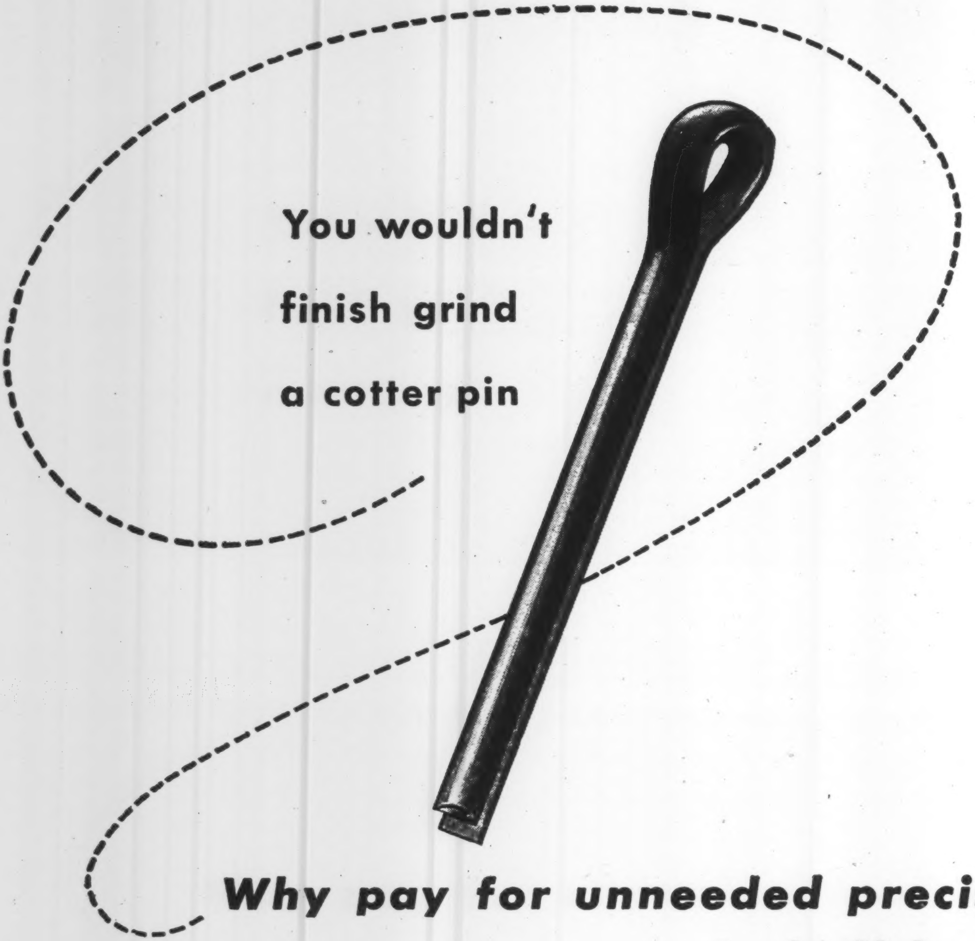

Why pay for unneeded precision in ball bearings?

In many applications where speeds and loads are moderate, you don't need a precision bearing. When this is the case, Schatz "Commercial" Ball Bearings can cut your costs by as much as 85%—*without any sacrifice in operating efficiency!*

Why are savings like this possible? Because "Commercial" Ball Bearings are designed to wider tolerances than precision bearings...because they are available unground, partially-ground, or fully-ground. And, because, in almost all cases, cages are not used.

If you have an application where speeds and loads are moderate, it will pay you to look into Schatz "Commercial" Ball Bearings. To learn how you may save, write for literature described below.

THE SCHATZ MANUFACTURING COMPANY
6760 Fairview Avenue, Poughkeepsie, New York

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Dishwashers • Outboard motors
Automobile steering mechanisms
Elevators • Box machinery
Office equipment
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The oldest, largest manufacturer of "Commercial" ball bearings

SCHATZ
"Commercial"
BALL BEARINGS

Technical literature available:
Schatz Catalog 11 contains drawings and specifications of Schatz Ball Bearings.
Technical Bulletin tells how to determine proper type and size "Commercial" Ball Bearing for various speeds and loads.
Nylon Bearing Parts discusses advantages of nylon parts in "Commercial" bearings.

He listens by looking...

And why not? It takes the guesswork out of test work.

QUIET BALL BEARINGS are longer running, smoother running, and stand up better under heavy loads.

That's why Federal inspectors rely on their eyes rather than their ears when testing the sound of a bearing. They use an Anderometer, a highly sensitive machine which picks up a bearing's slightest whisper and translates it into electrical impulses. By glancing at the dial indications, the inspector can easily tell if the bearing measures up to Federal standards.

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Supplying these facts is the important function of Trostel research—supplying them out of experience wherever possible; developing new compounds and impregnations where existing materials are found wanting.

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TROSTEL packings

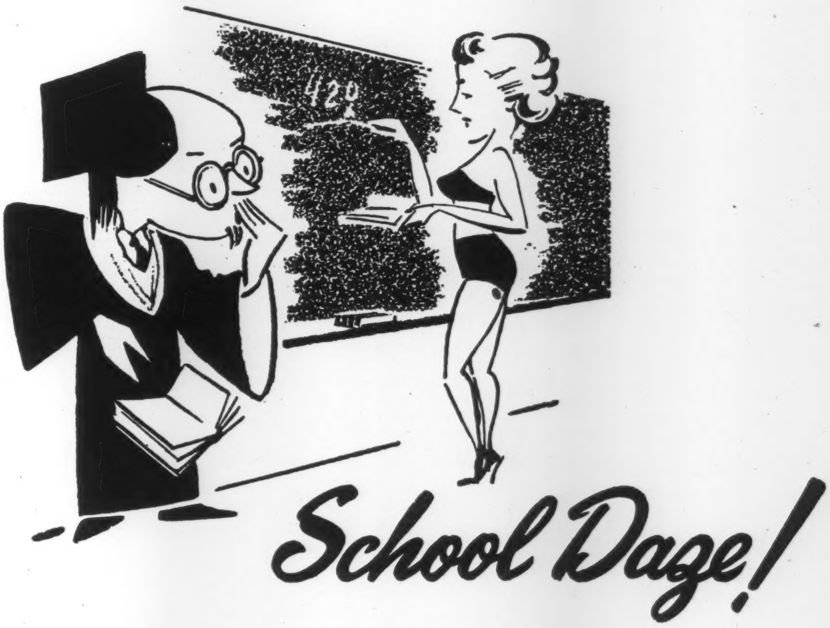
Adapts Oil Filter For Water Service

All models of Synclinal filters will be adapted for filtering water, announces Marvel Engineering Co. Presently producing filters for hydraulic and other low-pressure oil recirculating systems, the company is making the additional line available as a result of requests for adaptation of the Synclinal filtering principle to water filtration.

No changes have been made in the basic design. Line types still operate in any position and may be serviced without disturbing pipe connections. Both sump and line types may be disassembled, cleaned and reassembled while installed. Sump type filters are available in capacities from 5 to 100 gpm and line types from 5 to 50 gpm. Monel mesh sizes range from 30 (coarse) to 200 (fine). Complete engineering data on the new filters are available from the company at 627 W. Jackson Blvd., Chicago 8, Ill.

Traveling Exhibits Show Correct Use of Cylinders

A new fleet of mobile units is now on the road showing the proper use and testing of air and hydraulic cylinders. Following the success of Miller Motor Co.'s original "College of Cylinder Knowledge," the bus exhibits are designed primarily to instruct personnel in plants to be visited, and consist of many cylinder situations in actual operation. One special exhibit presents a striking example of the modern development of dual pressure boosters, while another shows how air and oil can be used



Just because that bathing suit is proper at the beach, she shouldn't assume it's proper for the classroom, too!

And just because one bearing is best lubricated by one particular grade of oil, you shouldn't assume that the same oil is best for *all* bearings on that machine. In many cases it isn't.

OIL CUPS permit you to lubricate each bearing with the oil best suited to that bearing—thus prolonging bearing life, reducing maintenance costs, cutting down-time, boosting production. And oil cups fortunately *cost very little.*

Gits oil cups have been the standard for industry for more than 40 years. Gits Bros. has the largest selection of oil cups available anywhere. Call on Gits Bros. for a prompt, efficient solution to your lubrication problems.

Write for free Catalog No. 60-A

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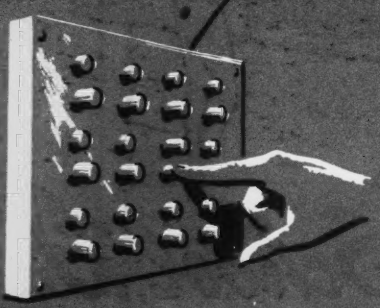

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SOLUTION... LEDEX CIRCUIT SELECTORS

Ledex Circuit Selectors and Stepping Relays are widely used for remote control of complex circuits to assure top product performance. They are powered by dependable Ledex Rotary Solenoids . . . available with various types of mountings . . . will control practically any number of circuits . . . and can be custom-engineered to fit your product. Let Ledex Engineers work with you to produce an efficient Ledex Circuit Selector or Stepping Relay for your product. Write today for complete information.

G. H. Leland INC.

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together in one cylinder unit to give smooth hydraulic power from ordinary plant air input. Like the original "College"—a converted, luxurious house trailer, which is still in service—the new units will be demonstrated at industrial plants by appointment.

◆

Battelle Memorial Institute, Columbus, O., recently broke ground for a new million-dollar laboratory building. Approximately 300 industrial firms, as well as the Air Force, Army, Navy and Atomic Energy Commission, are sponsoring research studies at Battelle.

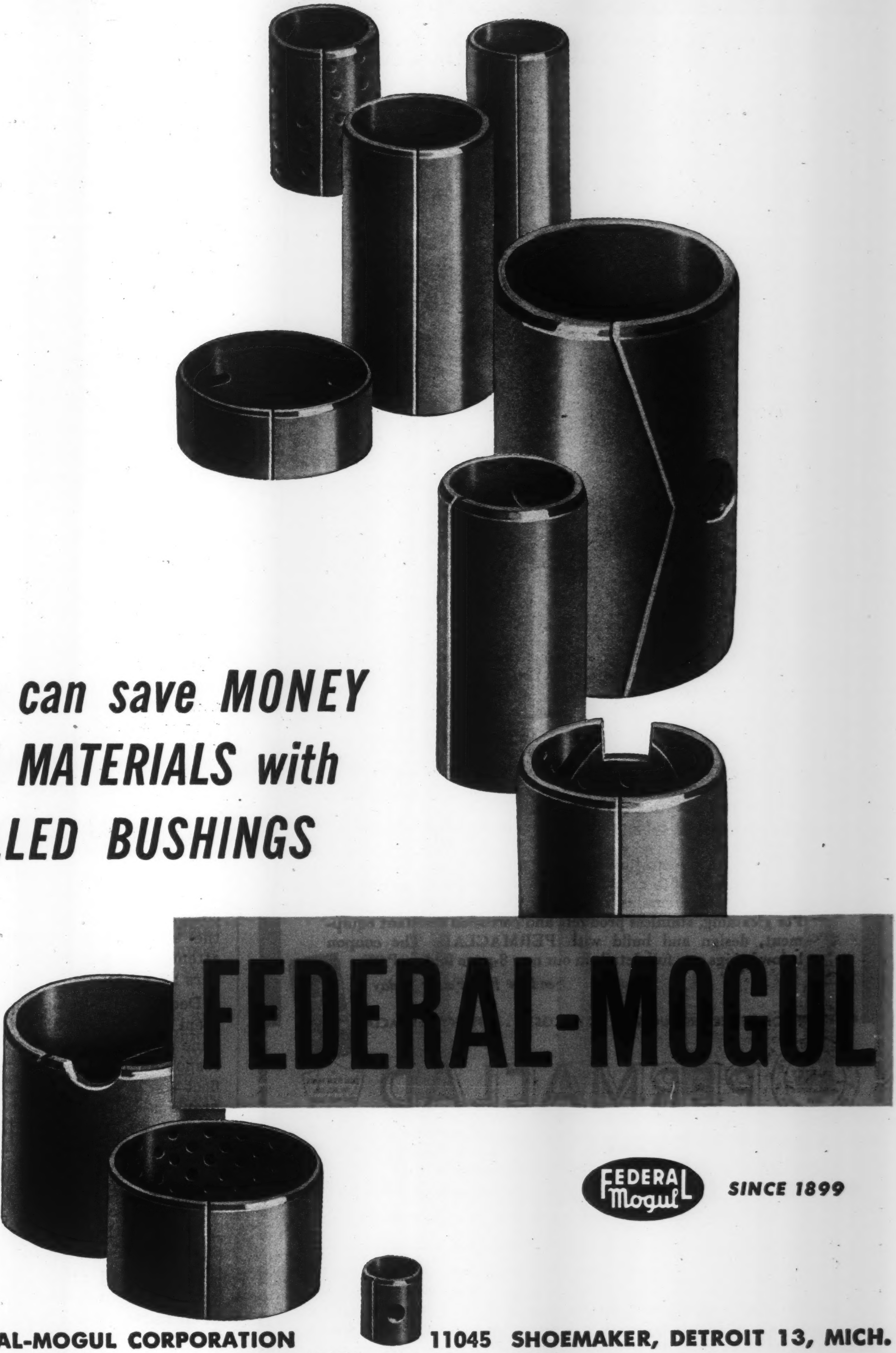
ASME Presents Program At Centennial of Engineering

A program of 37 sessions, during which 97 papers were presented, was the feature of the fall meeting of the American Society of Mechanical Engineers in Chicago. Celebrating the Centennial of Engineering, the ASME Meeting featured today's technical outlook and present-day developments in many fields.

At the International Presidents' Luncheon, R. J. S. Pigott, president of ASME, keynoted the four-day session with an address, "What Is Not Yet, May Be!" The Calvin W. Rice Lecture was delivered by Colonel Lyndall F. Urwick of London, whose subject was "Management's Debt to the Engineer." The lecture honors Mr. Rice, who served as secretary of ASME until his death in 1934. U. S. Senator Ralph E. Flanders of Vermont spoke on the relationship of engineering and government in delivering the Roy V. Wright Lecture on "Engineering and Politics."

The Machine Design division participated in three technical sessions, including joint sessions with the Safety and Lubrication divisions. Subjects of the seven papers presented at these sessions included elements of machine guarding, critical whirling systems of shafts, and slider-bearing lubrication.

In addition to the technical papers and addresses, ASME mem-



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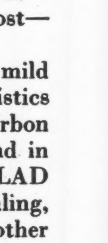

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bers present attended a specia performance of the Engineerin Centennial pageant "Adam t Atom," besides being taken o tours of the Museum of Scienc and Industry and other feature of the Engineering Centennial.

Management development wa one of the major subjects of discussion. A conference on management development in the western hemisphere was held unde the auspices of the Internationa Committee of Scientific Management, and a round table discussion on management developmen was also included.

Report on Materials

According to latest reports, the steel situation seems to be softening much faster than predicted immediately after the steel strike. One of the biggest factors in the quick easing of steel is a fast return to high production by the steel companies. The second cause is a drop in consumer demand—attributed in some quarters to secondary effects of the steel strike on employment.

Steel production rose to 100 per cent of capacity by early last month—a recovery which was quite a bit speedier than first forecast by government and industry observers. And although November 30 was the original target date for completing carry-over orders from the strike, steel companies were attempting to complete these orders by September 30.

Decontrol predictions, which seem to change like a weathervane on a windy fall day, have correspondingly been revised to reflect the latest situation. Although previous indications were that decontrol would be delayed for about a year (MACHINE DESIGN, September, Page 248), current estimates are that CMP stands a good chance of being revoked during the spring of 1953, with a possible open-end CMP by the first quarter.

Copper and aluminum are virtually in balance and the situation in these two metals is evidently not considered severe by NPA since a recent NPA order permits their use for decorative purposes on consumer goods. Many manufacturers have already been advised by NPA that there is no longer need to reduce usage of these two metals.

Rules on the use of conversion steel have already been relaxed—although the high cost of this type of steel and its relatively limited use restrict its application. And at press date, it appeared that additional supplies of steel, over and above the 80 per cent of third-quarter figure originally settled on by NPA, would be available.

The first step may be an open-end CMP, with steel available without tickets provided mills have open space at the expiration of lead times. This type of decontrol would allow military requirements to be filled first, yet permit free distribution of steel to consumers.

Long Range View: The Paley Commission which has acted as the President's advisory commission on materials policy, recently issued a formal report on the long-term outlook for materials. In five volumes, the report presents some conclusions which may have a very definite effect on the philosophy and approach to new developments and designs in the next 25 years.

The general conclusion reached by the Commission is that the United States will be forced during this time to realize that efficient conservation, use and development of sources of supply will be increasingly necessary. In support of this observation, the Commission mentions some interesting facts.

The quantity of most metals and mineral fuels used in the United States since the first World War exceeds the total used throughout the entire world in all of history preceding 1914. Although almost all materials are in heavy demand, the hard core of the materials problem is minerals. By 1975, demand for minerals as a whole, including metals, fuels and nonmetallics, will rise about 90 per cent—or almost double. Demand for energy in all forms will also double.

The domestic resource base is insufficient to meet this demand.

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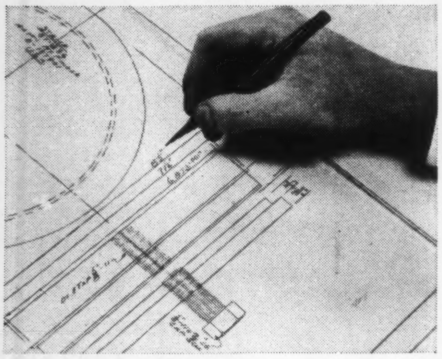

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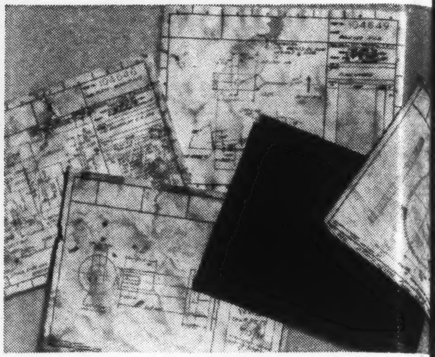

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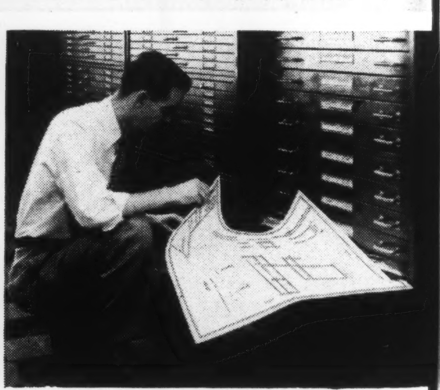

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This condition has been a long time in the making, but it was not until the 1940's that we completed the change from being a raw materials *surplus* nation to being a raw materials *deficit* nation. Whereas at the start of the century we produced some 15 per cent more raw materials than we consumed, by midcentury we were consuming 10 per cent more than we produced.

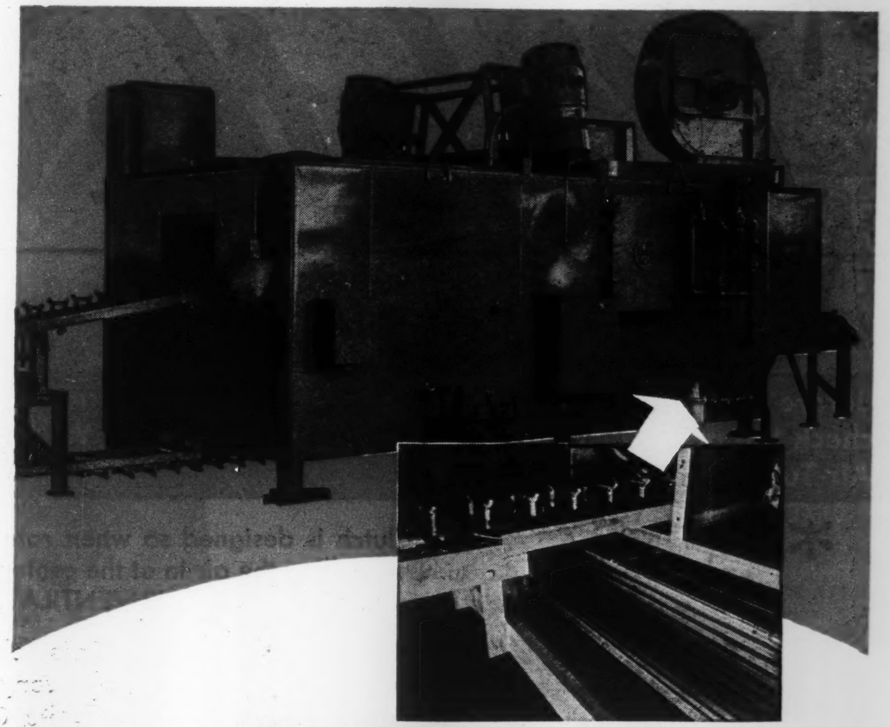
What are the implications of this constantly tightening materials situation? Absolute shortages are not the threat to the materials problem. We need not expect we will some day wake up to discover we have run out of materials and that economic activity has come to an end. The actual threat in the materials problem lies in a slow tightening of supply, leading to rising costs and gradual economic strangulation.

The challenge, therefore, lies in two areas. As the Commission report points out, new domestic sources of materials can be found, and we can import larger quantities of materials from free nations. These measures are, of course, advocated.

Of prime importance to designers, however, is the third recommendation—altering our patterns of use away from scarce resources and toward more abundant ones.

As the report points out, "Some of our consuming habits are extremely costly in scarce materials. We blow some 125,000 tons of lead a year into the atmosphere, lost forever, from the exhaust pipes of automobiles because we like quick pick-up on the road. *We waste materials by over-design and over-specification.* Often a trivial change of taste or slight reduction in personal satisfaction can bring tremendous savings."

The solution, from a designer's viewpoint, is obvious. "Using resources today is an essential part of making our economy grow; materials which become embodied in today's capital goods, for example, are put to work and help to make tomorrow's production higher," says the report. "Effective conservation calls for the efficient development and use of resources. . ."



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In building several of these motor block washers for a large automobile manufacturer, Centri-Spray, Inc., Detroit, Michigan has found that the use of Platecoils has 6 important advantages.

1 **Higher heat input per cubic foot for quicker heat-up.**

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Why not investigate using Platecoils in your products? You will find, as other manufacturers have, that Platecoils save time in estimating . . . that Platecoils save time and labor in fabrication . . . and that customers are better satisfied with Platecoil performance. ***Write today for Bulletin P71.***

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*Pick the Clutch

Before you specify or change clutches on your machines, check the many advantages of these three types of Wichita Air-Tube Disc Clutches.

- * **COOLER RUNNING:** The Clutch is designed so when rotating, it acts as a centrifugal blower, pulling the air in at the center and discharging it at the outside surfaces. POSITIVE VENTILATION!
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- * **ENGINEERED AND MANUFACTURED** in both Low Inertia and High Inertia, Standard and Special Ventilated types.
- * **GREATER LIFE:** Many tests have been run on Wichita Clutches where single engagements and disengagements have been measured to exceed 2½ million cycles. _These clutches are still in operation as originally furnished._

  Lining life is proportional to the heat generated, therefore, _the cooler the clutch, the longer the life!_
- * **LESS MAINTENANCE:** Simplicity of Design makes for easier maintenance when necessary. NO ADJUSTMENTS! NO LUBRICATION!
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- * **WIDE RANGE OF CAPACITIES:** 4,000 inch pounds to 4,000,000 inch pounds.

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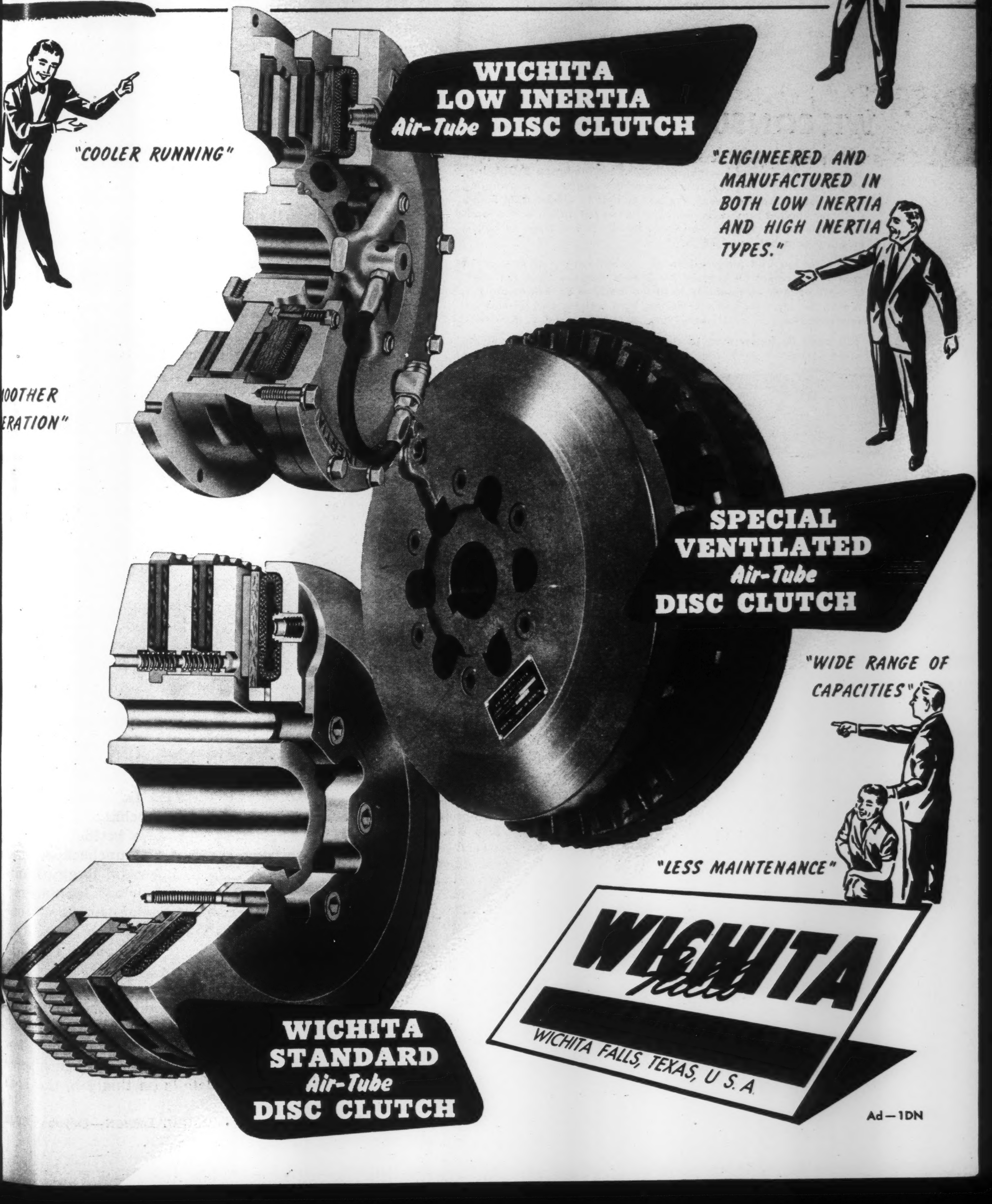
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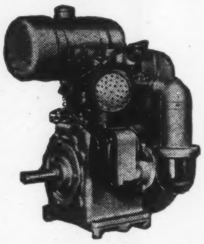

Models ABN, AKN, AEN 4-cycle single cylinder, 3 to 8 hp. Other models, up to 30 hp.

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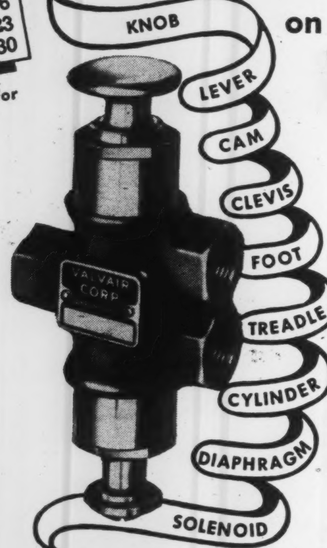

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Stress Relief

RESUMING his portrayals of engineering department rogues, J. P. Henderson presents a familiar character this month.

The Closet Engineer

In every engineering office we can find at least one man in a semi-responsible position, or who should be in one, who can be described as either the "old clothes man" or "Joe College." Although these two types are at opposite ends of the sartorial rainbow, they have one thing in common: a failure to conform in the matter of dress.

Management and executives in a manufacturing concern are generally conservative. This attitude often carries over into the way they dress. Joe College, regardless of whether he is just out of high school, or left Siwash twenty years ago, is the type who may appear at work in moccasins, a plaid shirt, and no tie. The "old clothes man" is equally as conspicuous with baggy pants, an old sweater and unshined shoes.

Now, it is probably everyone's right to dress as he pleases within the bounds of decency. If an engineer chooses to be such a rugged individualist, he may, but he should do it with some appreciation of what it costs him. And it can cost plenty.

The kindest thing that can happen to him is to be told about it. If the boss takes the attitude instead that either of these characters is old enough to know better and lets them both go on unchecked, then both Joe College and Baggy Pants finally become "closet engineers."

Let us examine the way one rates this title.

A district sales manager is in from the New York office, possibly with a big customer in tow. Both the salesman and the customer are vitally interested in that new Model K which will be produced in a few months. To be able to discuss some of the details on this job, the boss would like to be backed up by the engineers who have been most concerned with its development. During the conference, the time comes to go to lunch. A big hotel, the country club, the athletic club? The sales manager whispers to the boss, "We can't take that character; no tie, no coat."

Important customers come in, concerned with a device that the "old clothes man" has worked on. Logically they should discuss the project. But if the boss considers that such a meeting will not reflect credit on the company or his department, the conference goes on without the appearance of the engineer most capable of adding to the facts.

A closet engineer then is the man who is hidden in the closet when important people are around. Over a period of years, he lacks the broadening influence that can come from outside contacts. He is obviously not material that can be promoted without a major upheaval in his habits.

Have you ever been invited to a luncheon with company officials, important customers, or salesmen? Have the other people around you been invited while you have always been left out? Take stock of yourself!

—J. P. Henderson

Sometimes we think Henderson could have written copy promoting the sale of special soap or chlorophyll products. Next, here's another idea that is aimed, of course, at the other fellow.

The First Move

The average man on the job probably thinks that if he does his work from day to day, and does it well, he's in line for more pay and a promotion. Why?

Why should any sensible employer raise a man's pay if he is doing just what he's paid to do? It's a stalemate. Everybody's even. The employee does what he's suppose to, and the employer pays him what he thinks the job is worth. While I say that everybody's even, I don't mean everyone is satisfied. The employee wants more money, of course.

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Right—Entrance to offices of Fairfield's new plant in Lafayette, Indiana.
Above—Hobbing Spur Gear.

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ent equilibrium going to be upset?

As an employee, you know exactly how it could be upset. If you get a nice juicy raise, you will do more work and justify the increased pay, you tell yourself. Then, everything will be fine until by some miracle you get the next raise, and take more responsibility, and do still more work.

That's a splendid idea, but the trouble is it doesn't work that way. Whether you like it or not, whether you consider it fair or not, it's up to you to put out the extra work first. The boss holds the purse strings; your job has a price label on it, and he is not going to raise your pay just because he likes the color of your eyes or the part in your hair.

It's your move first. Only when you have been doing a better job, an obviously better job for months, can you expect that the boss is going to do anything exciting about it.

Even then, you may have to suffer a while longer. Next year, there's going to be an opening, and because that extra work you've been doing finally penetrated the boss's consciousness, he has you marked. You will get that raise in position and pay.

You may see no justice in such a system but, like it or not, it's the way the game is played. Certainly no one has ever advanced any evidence to show that the alternative is true—work less and less and expect a raise and a promotion.

Who? That fellow? He's the president's nephew.

—J. P. HENDERSON

G. K. Chesterton neatly said it this way: "I do not believe in a fate that falls on men however they act, but I do believe in a fate that falls on them unless they act."

They Say . . .

"The companies most successful in meeting their management manpower requirements will be those which are most successful in getting the best out of the people they already have." LOUIS A. ALLEN, *personnel administration manager, Koppers Co. Inc.*

Design Abstracts

(*Continued from page* 201)

does his company.

Optimism is a virtue the world around. All of us have known the man with a negative attitude. He can be convinced, but it takes hours of valuable time. He usually is the ultra-cautious conservative type. He never can be an outstanding member of any organization.

These, then, are a few of the qualities that help make a success of any chosen career. One's education represents the minimum qualification. It does not guarantee success. The qualities discussed, on the other hand, if one has them in full measure, will insure his rise above the median, not only in engineering, but in any profession.

From an article entitled "Qualities Industry Wants in Its Engineers" appearing in the May 1952 *issue of the General Electric Review.*

Pulse Excitation of Resistance Strain Gages

By J. G. Yates, D. H. Lucas and D. L. Johnston*

PULSES of a few microseconds duration have been used successfully in a new technique for exciting resistance strain-gage bridges. The method is specially applicable to compact multichannel equipment with cathode ray tube display.

It has been found that impedance measurements can be made by exciting a bridge circuit with rectangular pulses of voltage instead of with dc or ac. Thus, in a resistive bridge, an output pulse is obtained at each repetition where height is a measure of the degree of the unbalance of the bridge. When applied to strain gage measurement the height is a measure of the instantaneous strain. The pulse may be amplified in a suitable capacitor-coupled amplifier, so that the value of strain is reproduced

---

*J. G. Yates is at the Engineering Laboratory, Cambridge, England. D. H. Lucas formerly was and D. L. Johnston is at the Research Laboratories of Elliot Brothers (London) Ltd., Borehamwood, England.

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To mount this thermostat successfully and meet these rigid in-service specifications, many manufacturers tried a wide variety of materials. But Roth—*and only Roth*—developed a mounting that would meet all three service requirements at reasonable cost.

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Design Abstracts

continuously but without the zer drift associated with dc amplifiers.

In *Fig.* 1 a bridge ciruit and the forms of input and output pulses are shown. The unbalance voltage of the bridge has an initial "spike," due to stray reactance, which is separated in time from the plateau or final level of the output pulse. Only this final level is displayed on the cathode ray tube.

Successful results have been obtained with exciting pulses 10 microseconds long, repeated 10,000 times per second to each bridge circuit. Screened leads are not used as a twisted pair of thin flexible wires is satisfactory, the capacitance being about 10 picofarads per foot and the inductance 0.5 microhenries per foot. Leads up to several hundred feet in length have been used.

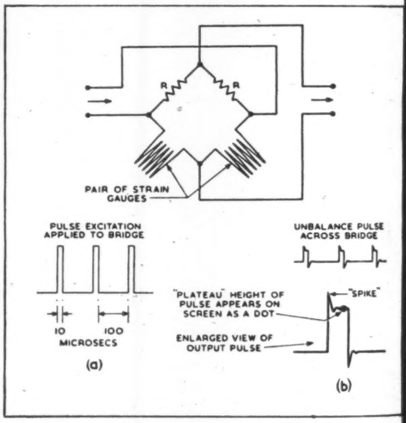
R
R
PAIR OF STRAIN GAUGES
PULSE EXCITATION APPLIED TO BRIDGE
UNBALANCE PULSE ACROSS BRIDGE
10
100
MICROSECS
(a)
"PLATEAU" HEIGHT OF PULSE APPEARS ON SCREEN AS A DOT
"SPIKE"
ENLARGED VIEW OF OUTPUT PULSE
(b)

Fig. 1—Bridge circuit for pulse excitation. Form of input pulse is shown at *a,* form of output pulse at

Multichannel Display

One of the chief advantages of pulse excitation lies in the application to multichannel display. By exciting the gages at different times, all the output pulses can be handled by a common amplifier but displayed separately on a cathode ray tube. Pulse excitation equipment is not as simple as a dc or an ac amplifier for a single channel, but it is superior for multichannel display. A ten-channel apparatus can be no bigger than about three separate amplifier channels and

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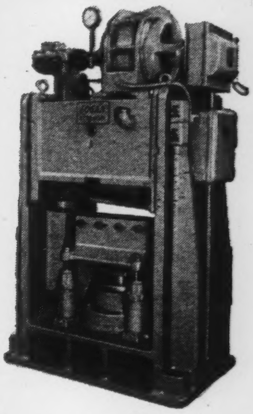

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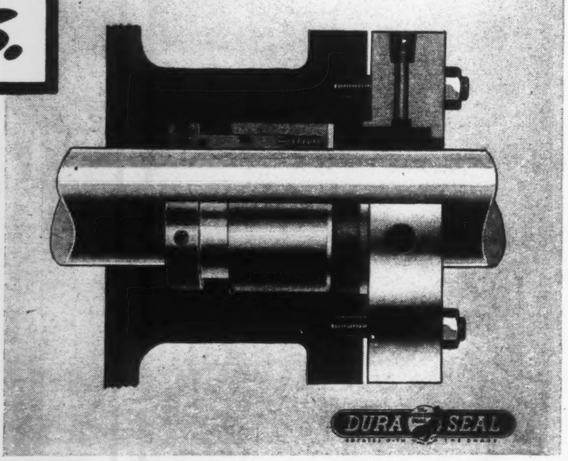

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The amplitude display is a ro of dots when there is no strain With static strain the dots are displaced, and with static and dynami strain, the elongated line show total amplitude, and its cente point shows the mean static load In the waveform display the spot are initially spaced out verticall instead of horizontally, and ar then deflected horizontally, relatively slowly, by an adjustabl time-base, as on an ordinar cathode-ray oscilloscope.

If the time base is stopped, continuous-motion film camer may be used to provide the time displacement. For continuous records a cathode-ray screen of fas decay is desirable to avoid smea on the photograph. A 16 mm cin camera has been used, and here persistent screen was found to b more suitable in order to reduc the stroboscopic effects due t beats between the speeds of camer shutter and time-base sweep.

From a paper entitled "Pulse Excitation of Resistance Strai Gages for Dynamic Multichanne

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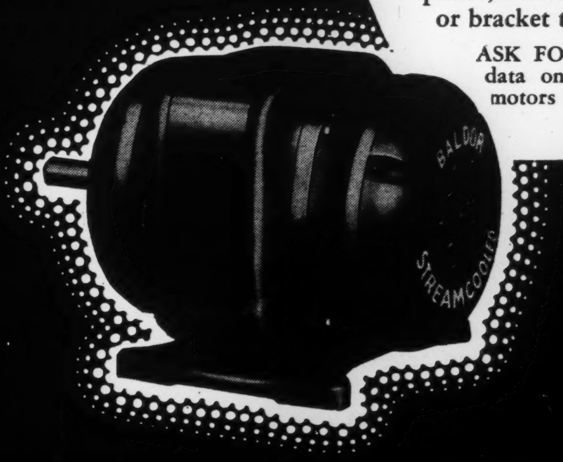

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Observation" presented at the Spring Meeting of the Society for Experimental Stress Analysis in Indianapolis, Ind., May 1952.

Lightweight Sandwich Structures

By B. Del Mar and H. Stumpf
Del Mar Engineering Laboratory
Los Angeles, Calif.

CONSTANT search for stronger, lighter structural materials and construction methods has focused considerable attention on the possibilties of honeycomb core structural panels. Panels incorporating a lightweight core, which separates and is bonded to thin high-strength facing materials, are structural units with very high strength - weight and rigidity-weight ratios. Such panels, with their neat appearance, insulation properties and simplicity of assembly, are suitable to many applications especially in the design of airborne equipment.

Of all of the so-called "sandwich construction" panels, those incorporating a manufactured honeycomb core material appear to be the most promising. Honeycomb core materials are manufactured from thin sheets into a bulk assembly of uniform structural shapes capable of withstanding shear and compression loads. Most of these have been hexagonal in shape, resembling honeycomb cells. There are several core materials now being manufactured in quantity. Among these are 4 and 8-oz cotton duck cloth, 60, 70, 110 and 125-pound Kraft paper, glass fiber cloth and 0.002 through 0.006-inch thick aluminum foil. A number of other materials are being manufactured experimentally. These materials are manufactured into honeycomb cores having a variety of cell pitches, with ¼-inch and 7/16-inch being the most common. The paper and cloth are impregnated with resin which is cured to hold the core shape. Panels can be fabricated by facing the core with metal, wood, plastic, cloth or paper

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sheets. The facings can be bonde to the honeycomb with any one o a variety of commercially available resins. These core material are available for any desired thickness of panel; however, the majority of design requirements hav been met with panels less than fiv inches thick. Available mass produced cores are limited in lengt and width by existing productio equipment. Core materials are produced in sizes considerably les than those of standard facing materials. Splicing of core segments therefore, is required for their fabrication into panels.

Honeycomb core materials, wher bonded into panels, allow the face materials to be stressed up to their yield strength. The core carries shear loads, resists tensio and compression loads perpendicular to the plane of the panel, and stabilizes the faces, preventing premature buckling. For highe strength cores, bonding of the components of the panel is increasingly critical.

Shear and compression strengths of core materials vary almost directly with the weight of the core; the heavier core being the stronger. Some relative strengths, as obtained from published data are shown in TABLE 1.

Rigidity in honeycomb core panel construction is a function of the total panel shape; with a core material weight-rigidity ratio probably highest for magnesium foil core and then, in decreasing order, aluminum foil, impregnated paper and impregnated cloth. Honeycomb construction shows a consid-

Table 1 — Strength Properties of Honeycomb Cores

Core Material	Core Weight (lb/ft³)	— Strength — Comp. (psi)	Shear* (psi)
Paper, 60 lb†	1.70	130	40
Paper, 70 lb†	2.18	140	51
Paper, 110 lb†	2.95	240	53
Alum. foil, 0.003 in. .	4.20	455	85
Alum. foil, 0.002 in. .	4.30	475	90
Cotton duck, 4 oz† .	4.70	380	90
Paper, 125 lb†	4.90	620	162
Alum. foil, 0.004 in. .	5.40	660	140
Alum. foil, 0.003 in. .	6.10	780	175
Alum. foil, 0.004 in. .	7.85	1090	270
Cotton duck, 8 oz† .	8.60	1000	204

* For transverse core direction only. Longitudinal direction values are approximately 1.6 times greater. † Impregnated.

erable advantage over fabricated wood or metal panels on a rigidity-weight basis.

The insulation properties of a given thickness panel are a function of the core material used, the thickness of the sheet used in its manufacture and the size of the reticule of each honeycomb. Cloth, paper and metal, in that order, vary from good to poor thermal insulators. Cells of the core may be filled with a lightweight, rigid plastic foam to increase the panel insulation properties.

Design Considerations

There are, however, certain definite limitations to lightweight core design. One is in the handling of concentrated loadings, particularly shock loadings. If the panel, with its thin facing material and lightweight core, is considered in much the same manner as any other lightweight skin panel construction, if the concentrated loads are taken over a considerable area of the panel, and if special consideration is given to eliminating or at least minimizing the tension loads in the core-to-face glue line, such loads can be handled quite efficiently. Previous design experiences have revealed a number of methods of designing for these concentrated loadings, and of using rugged core material to resist shock.

Actually there is no single performance characteristic of honeycomb panels which cannot be duplicated by some other method. When combined characteristics are considered, however, other methods lose what would sometimes appear to be their greater simplicity. For example, honeycomb panels have been utilized successfully in the construction of military lightweight trailers. A comparison of honeycomb panel advantages in these structures with respect to more conventional sheet - metal frame-type constructions reveals the good combination of physical qualities it provides:

1. **Rigidity.** A structure can be made as rigid by other methods but the weight and amount of material

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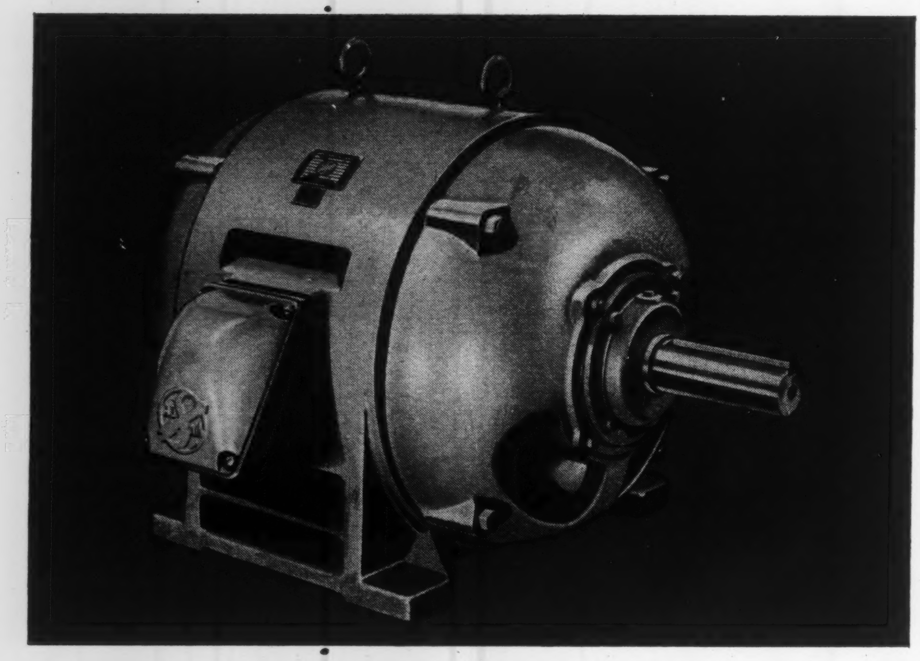

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needed will increase to a large degree. Honeycomb panel structure provides the most efficient placement of strong material to give strength and rigidity in bending — right at the outer surface. Furthermore, the surface material is kept by the honeycomb from forming shear wrinkles common to other thin sheet structures; thus these structures provide far less deflection in shear.

2. WEIGHT. The strength efficiency of honeycomb panel structure is very high in terms of material used. All surface material can be worked in compression to stresses which closely approach their block limit values instead of only an effective width of surface material adjacent to longitudinal stiffeners as in more conventional sheet structures. The result is a much lighter weight structure. However, bending strength is not the only consideration and when durability is made equivalent by a good rugged design, this weight advantage is cut down to a small margin.

3. INSULATION QUALITIES. The insulation quality of honeycomb panels is built right in to the structure; particularly when paper core or even cotton duck core is used. Edge closure strips on the panels conform to insulation requirements when made at least in part from phenolic or other plastic materials of low conductivity. Where a very high degree of insulation is required, and even radiant and convection heat transfer is to be held to a minimum, a lightweight foam material can be placed in the core reticules without seriously affecting the simplicity of the panels. Conventional frame construction, because insulation is more of a nonuniform proposition, is more apt to show frost spots in the interior in cold weather. Insulation between inside and outside surfaces in the region between frames of conventional structures can readily be provided and will perform well when new. However, after any extended service use, this insulation often tends to pack and settle. Usually it will require a time-consuming and costly installation procedure to avoid this. Right at frame stations, insulation can never be made highly effective in the conventional structure, and a thick insulation panel (often wood) is usually required for the whole interior surfacing. Here, then, a severe weight penalty is generally accepted and interior smoothness, durability and neatness are usually lost also.

4. SPACE. Honeycomb panel structure can be so compacted into thin

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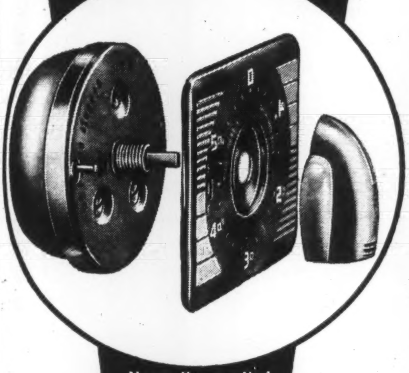

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walls that more interior space is available for electronic components and personnel in military lightweight trailers. To achieve an equivalent thickness and strength using conventional structure would require a more complicated multiplicity of framing.

5. SOUND DEADENING QUALITY. Conventional trailer wall structure leaves the outer surface sheets free to vibrate sufficiently in transit to amplify ground noise. Trailers using honeycomb panels are not only quiet inside in emplacement but are proving quiet in transit, even while undergoing tests on the Army Ordnance Belgian Block road at Aberdeen Proving Grounds, Maryland.

6. COST OF MATERIALS. Unit cost of materials when using honeycomb panel construction can be expected to be at least equal to and probably less than conventional frame construction, assuming equivalent physical characteristics are obtained by good insulation and appearance. The fact that a lesser weight and gauge of strong sheet material is required with honeycomb panel construction is the key to this saving.

7. ABILITY TO SEAL. Where tropical storm, flotation and stream fording requirements call for tight sealing of structural seams, honeycomb panel construction surpasses conventional frame construction because fewer rivets, bolts and seams are required to be sealed.

8. DURABILITY AND EASE OF REPAIR. When conventional sheet metal and frame construction is damaged in the field by collision or flying fragments, it is expected that the sheet and frame materials will become dented, twisted and bent. Honeycomb panel construction is probably no more resistant to such damage, but when it does occur the surface materials remain straight and supported at the edges so that a repair may be made on the flat surface by simple flat patches using sheet metal screws or blind rivets.

9. INTERIOR AND EXTERIOR NEATNESS. Honeycomb panel construction with sheet metal surfaces, on a military lightweight van trailer body, provides a smooth wrinkle-free solid feel and appearance to both interior and exterior surfaces. This surface should take and hold paint without checking over long periods, not only because very uniform surface temperatures prevail, but also since the skin does not wrinkle.

10. EASE OF ASSEMBLY. With honeycomb panel construction, each panel

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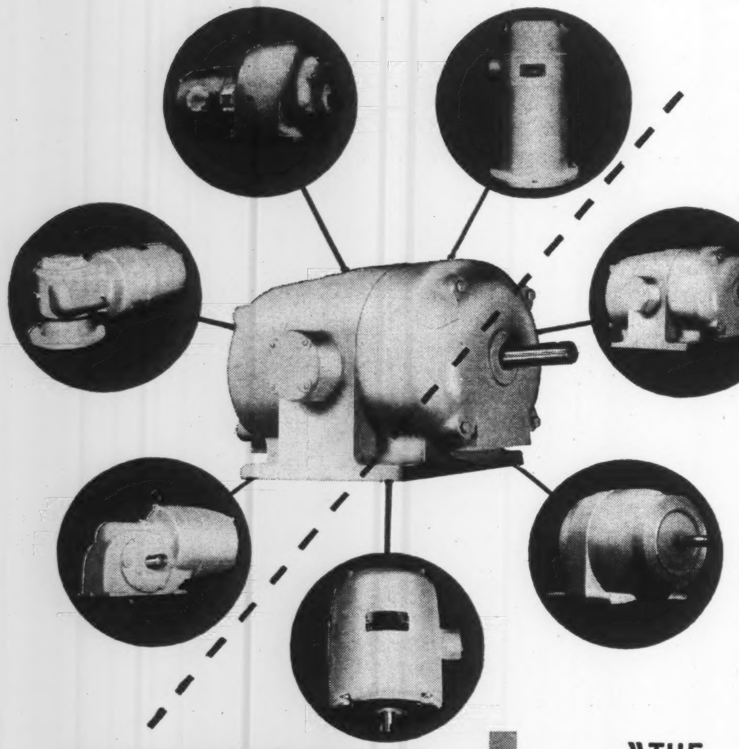

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is an individually sealed and complete component of subassembly. Conventional frame construction, therefore, will usually take longer in final assembly, a time when space and production line time is more costly. Honeycomb panel construction is also particularly suitable to use in trailer design where a portion or all of the structures must be knocked down for transportation in relatively smaller pieces such as is the case with the universally used GCA van trailers originally developed for the U. S. Air Force.

This type of trailer construction is not completely new, as trailers incorporating honeycomb core panel design have been recently developed and are being produced in increasing quantity. Other designs incorporating honeycomb core panels are also in production —doors, interior partitions, and various guided missile, target-drone and airplane components such as fins, partitions and floors. Arctic hut designs incorporating honeycomb core panel construction appear to be especially promising, and service experience is being accumulated rapidly.

Test Data Available

Honeycomb core panels, moreover, are now a recognized type of construction. In airframe companies, where much of the development work was accomplished, a considerable amount of test data has been accumulated, ANC documents have been written covering the material, design and servicing of this type of construction.

But it is of some concern to those who have been instrumental in introducing these light strong structures into military lightweight trailers and other airborne equipment, that in some of the future applications there is the possibility that honeycomb core will be misused, either in design or in fabrication. There are many special design and fabrication problems which must be considered. In extreme cases, failure to consider them may result in impractical designs or unsatisfactory products. Those in industry who are confident in the future advantages in

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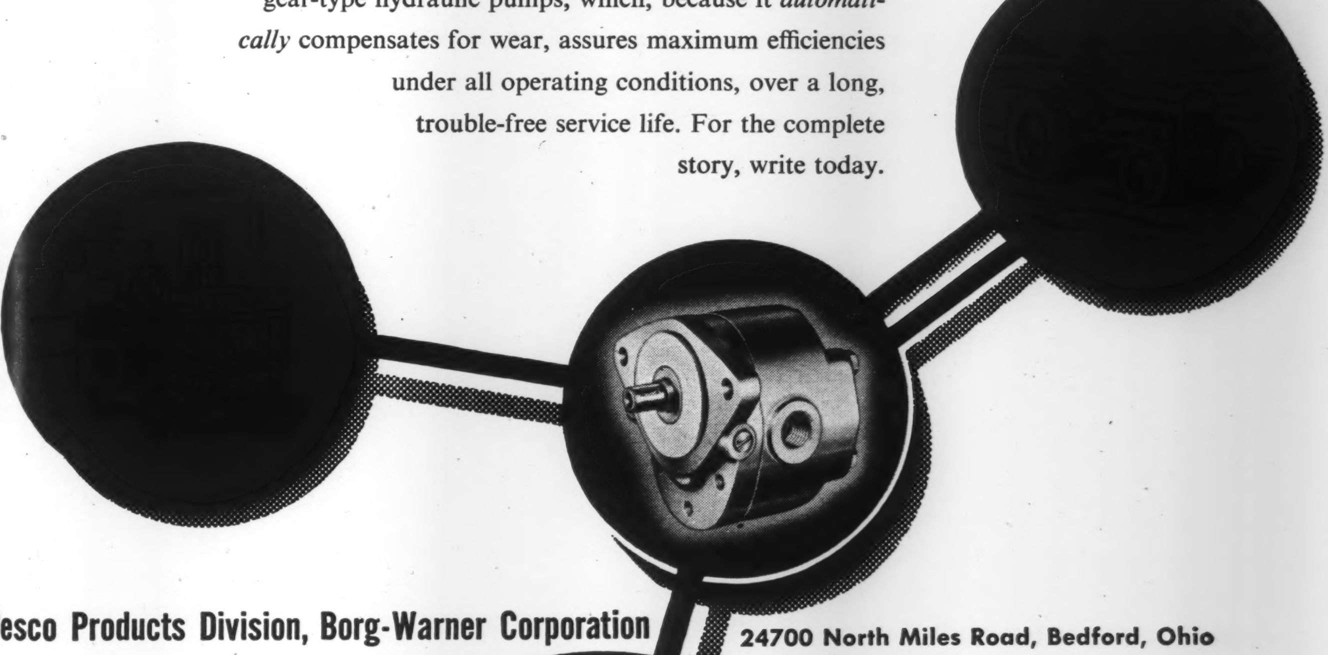

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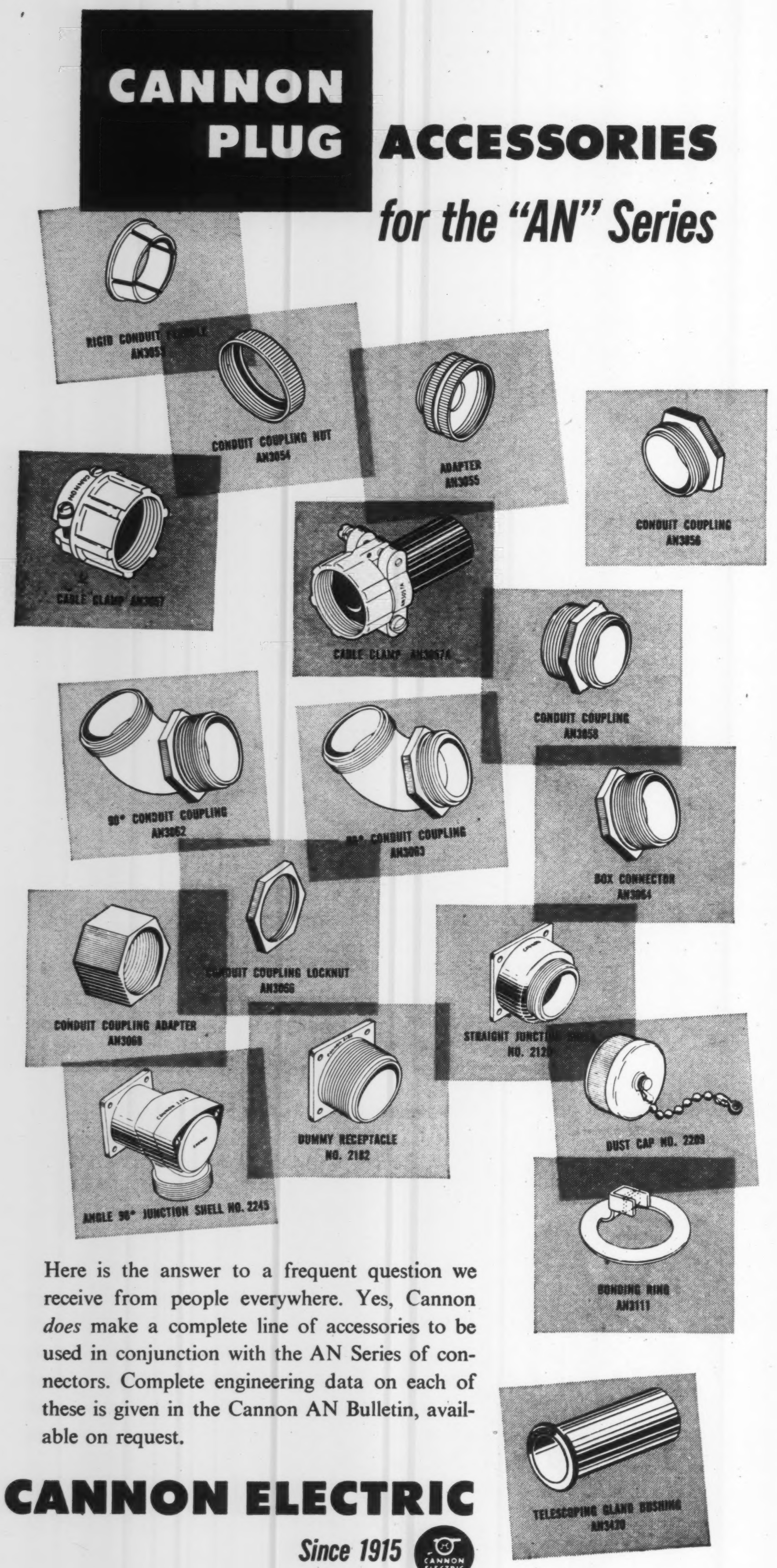
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developments of honeycomb constructions should continue their efforts for the proper use and handling of these lightweight core materials.

From a paper entitled "Use of Honeycomb Panel Construction in Military Lightweight Trailers," presented at the Spring Meeting of the ASME in Seattle, Wash., March 1952.

Nuclear Power Production

By J. F. Flagg and M. J. Gross

Technical Department
Knolls Atomic Power Laboratory
General Electric Co.
Schenectady, N. Y.

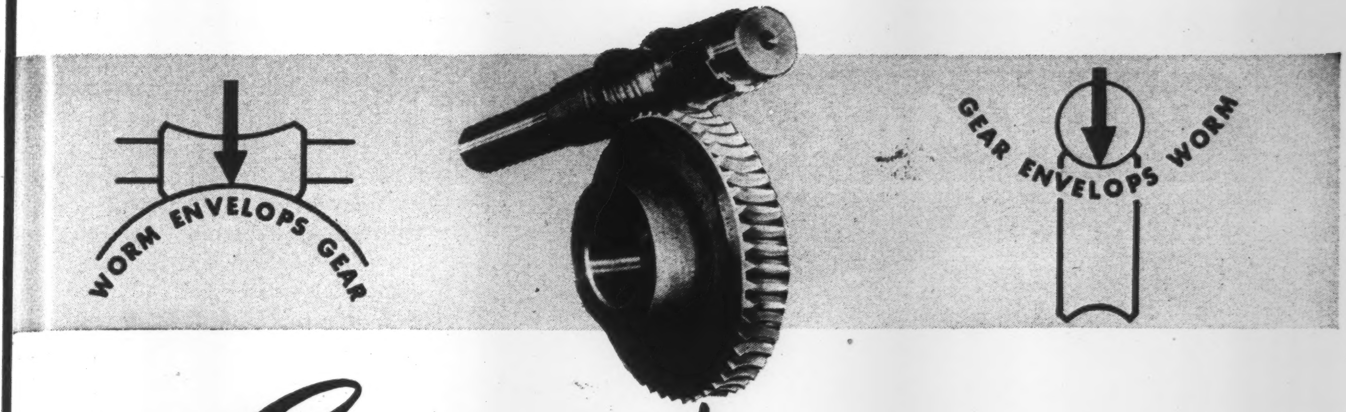
NUCLEAR fission is a particularly violent type of nuclear reaction produced in the heavier elements by bombardment, usually with neutrons. In this reaction the element in question is split into fragments of lower atomic number. The total mass of the fragments almost equals that of the original element. The small difference in mass shows up in the form of radiation, kinetic energy, and eventually heat.

Of the isotopes found in nature in substantial amounts, uranium 235 (U-235) is unique with respect to fission. An atom of this isotope, under favorable conditions, not only divides but also liberates enough new neutrons to support a continuing chain reaction of fission with other U-235 atoms. This chain reaction is the key to the release of atomic energy.

The energy release from fission of an atom of U-235 amounts to nearly 200 million electron-volts. This results from the conversion of mass to energy in accordance with the Einstein mass-energy equivalence law.

It takes approximately 3.1×10^{10} fissions to release an energy equivalent to 1 watt-second. Stated in more familiar terms, the complete fission of 1 gram of U-235 releases 24,000 kw-hr. The combustion of 3.3 tons of coal would be required to produce the same amount of energy.

Although electrical terms have



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been used for comparison because of their familiarity, the energy referred to appears primarily in the form of heat; it cannot, of course, be converted to electrical energy without appreciable loss. Furthermore, a portion of the energy is completely lost, for all practical purposes, because it is in the form of neutrons and radiation which are dissipated over a considerable amount of space.

As far as we know today, the only practical way of converting fission energy into electricity is through the intermediate steps of heat and mechanical energy, and the use of a turbine-generator. Thus, the fission chain reaction becomes merely another way of getting heat, and in that case the nuclear reactor is simply a substitute for the firebox and boiler of a conventional power plant.

Reactor Characteristics

The reactor may be characterized as a very special assembly of (1) nuclear fuel, (2) moderating material to control the energy of the neutrons given off, (3) heat-transfer media to remove the heat, (4) shielding to confine the intense radiation, and (5) means to control the rate of fission.

The efficiency with which heat taken from the reactor can be converted into useful energy depends upon its temperature, in accordance with the well-known laws of thermodynamics. The higher the temperature, the more efficient the possible conversion into mechanical and electrical energy. (In a modern steam-turbine power plant using a temperature of 1050 F, net efficiencies of the order of 36 per cent are obtained.)

Much has been written of a speculative nature about the economics of nuclear power, but it necessarily has been based on very nebulous information. Many more years of work may be required before the economic aspects are clear. For some years to come nuclear fission is certain to be an expensive source of electrical power which will not compete with conventional fuel—except in certain specialized field where advantage

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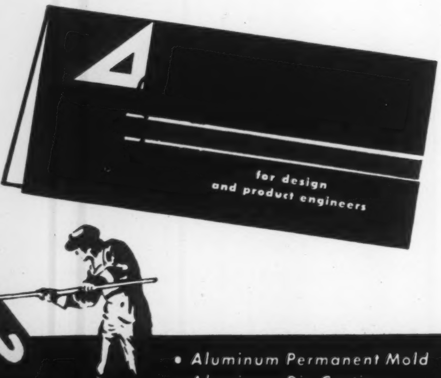

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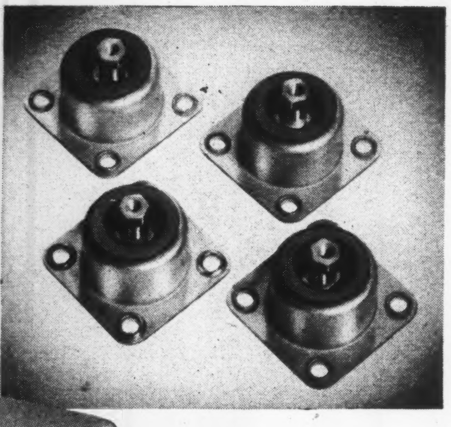

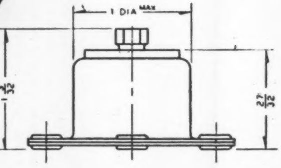

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may be taken of its unusual properties. This is not intended to be discouraging; on the contrary, nuclear fuel may, before too long, contribute greatly to progress in those specialized fields.

Even the cost of fissionable material is hard to determine accurately, because of the military conditions under which the plants have been built for its production. Whatever this material cost, it is only a part of the total cost of nuclear power. The overall figure must include the operating and fixed costs of (1) the fuel fabrication, (2) the nuclear reactor and associated heat-transfer system, (3) the turbine and electric generating equipment, and (4) the chemical reprocessing of the fuel. Compared with the costs of plant facilities for the conversion of ordinary fuels, estimates of these costs range considerably higher today.

Nuclear Fuel

The unusual properties of nuclear fuel that may be valuable in special fields include: (1) an extremely high energy potential per unit of mass, (2) the release of this energy without consuming oxygen as with other fuels, and (3) a potential ability to produce simultaneously both energy of commercial value and secondary fuel of military value. The first property is of great interest for ship propulsion, where the weight of conventional fuel is a limiting factor in cruising range. For the same reason, nuclear fuel is being given serious consideration for airplane propulsion. In this case, the reactor must operate at an even higher temperature than for ship propulsion and must not require excessively heavy radiation shielding. For submarine propulsion the release of energy without oxygen consumption is an added advantage. The Atomic Energy Commission has announced that work is in progress on two nuclear power plants for this special application.

The potential ability of nuclear fuel to produce power and secondary fuel simultaneously may offer the best opportunity for the initial economic and large-scale generation of electricity. It is interesting to note that the Atomic Energy Commission last year signed agreements with four industrial groups for studies of the possibility of private industry's building and operating reactors which are intended for this dual purpose.

It is probable that the reactors for large-scale generation of electricity will be built in locations that would preclude the possibility of endangering populated areas through malfunction or sabotage. If so, this would be only a temporary limitation, until more experience is obtained with the new hazards involved. Eventually, there is no reason to believe that such reactors cannot be made safe enough for operation anywhere.

The development of nuclear power has been in progress for about five years—and on a rather intensive basis, by industrial standards. It has benefitted, of course, from the great effort directed toward military ends. The fact that as yet no significant electric power has been produced is an indication of the magnitude of the scientific and technological problems involved. Progress is being made, however, and before too long nuclear power plants should be a reality. At first they will be expensive and of specialized value only, but as time goes on they undoubtedly will find an increasingly valuable place in our power economy.

From an article entitled "Nuclear Fuel for Power Production," appearing in the General Electric Review for March 1952.

Plastic Prototypes Aid Design Evaluation

By Wallace A. Stanley

Manufacturing Engineering Staff
Ford Motor Co.
Detroit, Mich.

MODELS have been widely utilized for development of both product designs and manufacturing processes because they are an efficient and often necessary medium to achieve innovations of design. They clearly show how to improve both function of

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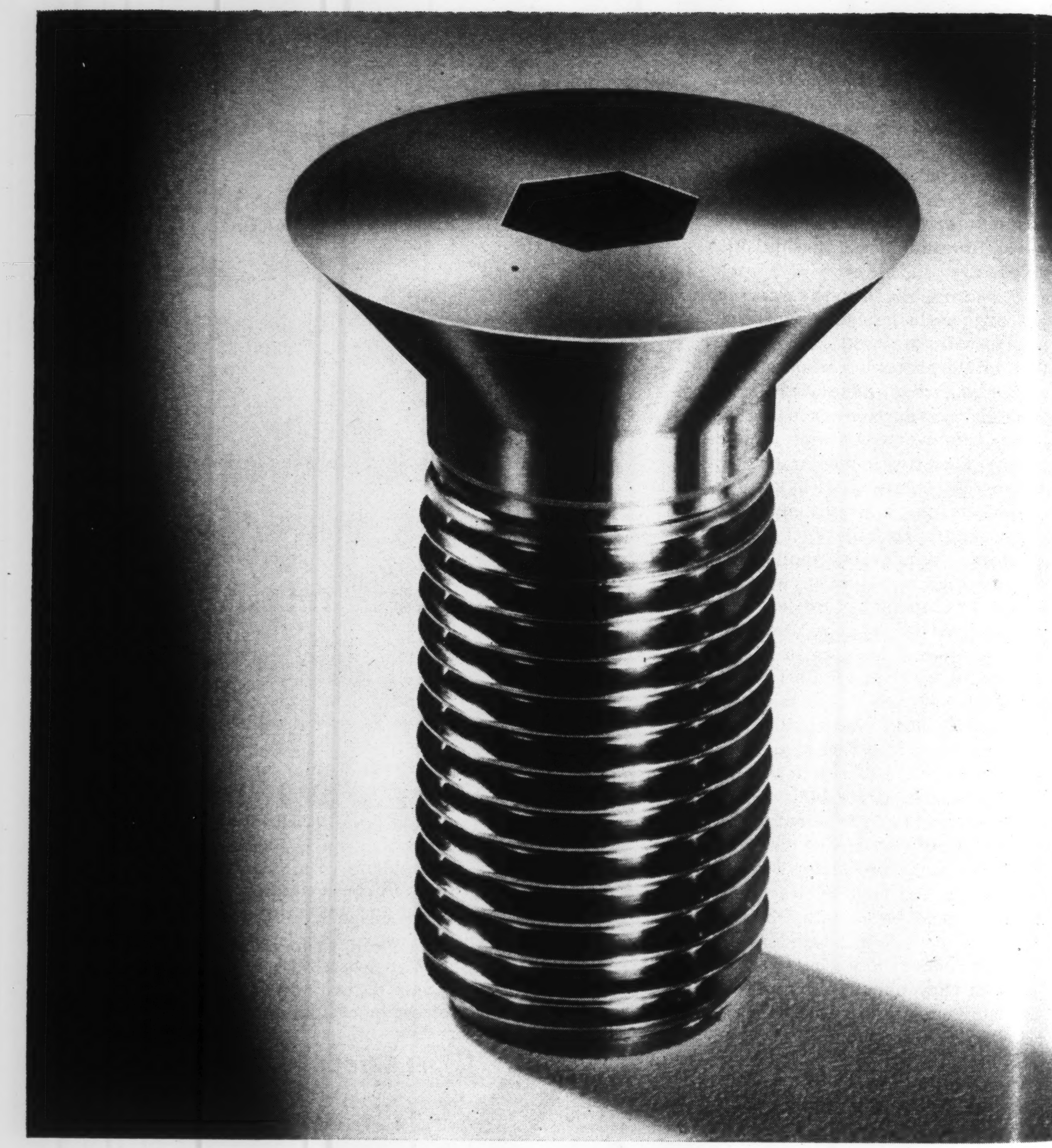

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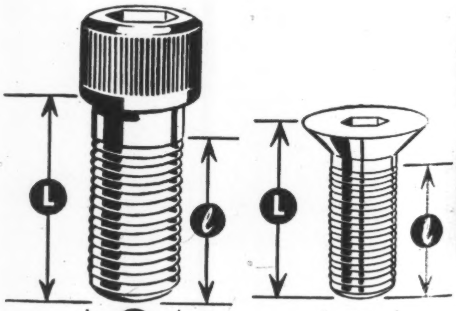


WHY IS IT THAT 75% OF ALL SPECIAL SOCKET SCREWS ORDERED FROM SPS HAVE ODD THREAD LENGTHS?

75% of all screws classified by SPS as *specials* have odd thread lengths, probably because of widespread unfamiliarity with thread formulas.

In many cases, *standard* UNBRAKO Socket Screws can be substituted. They will save you time and money. They are available from the stocks of your local distributor. Ask him or write us for your copy of UNBRAKO *Standards*. STANDARD PRESSED STEEL Co., Jenkintown 18, Pennsylvania.

What Are the Standard Thread Lengths?

The authority for the thread formulas used by SPS and other threaded fastener manufacturers is Handbook H28, Screw Thread Standards for Federal Services, National Bureau of Standards. It reads:

The length of the screw thread is measured from the extreme point to the last usable thread and shall be as follows:

American National rse Thread Series	$\ell =$ 2D + ½″ (where this length of thread would be greater than half the screw length). $\ell =$ ½L (where this length of thread would be greater than 2D + ½″).
American National e Thread Series	$\ell =$ 1½D + ½″ (where this length of thread would be greater than three-eighths the screw length). $\ell =$ ¾L (where this length of thread would be greater than 1½D + ½″)

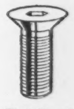
Screws too short to allow application of these formulas shall be threaded as close to the head as practicable.

SPS

JENKINTOWN PENNSYLVANIA

Knurled Head Cap Screw

Self-Locking Set Screw


Flat Head Cap Screw

Shoulder Screw

Dowel Pin

the product and efficiency of manufacture. There is often a substantial reduction of costs in the final product because so many factors are brought out clearly far in advance.

The logical combination of models as a medium and plastics as a material has been employed for some time for exhibitions, displays, sales campaigns, training classes, and occasionally for engineering purposes. However, for some reason, plastic models have not been used nearly as extensively as they could be as a development medium or as a means of working out design problems harassing both engineering and manufacturing.

Plastics Save Time

The primary reason for using plastics to produce prototype study models is the saving of time. Parts can be obtained in a matter of a few hours or days instead of the usual weeks required to make metal parts. In one single operation, plastic parts can be completely formed either by pressure or vacuum, after the plastic has been prepared and placed properly in or over the mold. As an example, plastic parts prototyping deep-draw stampings can be made in one operation whereas their counterparts in steel would have to be made by many operations. Back drafts and difficult drawing areas are of little concern to the plastic technician because he can compensate for these difficulties in making the mold and selecting the proper forming techniques.

The cost of making plastic prototype parts is negligible compared to making parts of metal by the conventional fabricating method. Further, when parts are handmade in metal, each duplicate part requires the same amount of work and time as the first part. However, in making plastic prototypes, after a form is once made, any number of duplicates can be made readily in a matter of only minutes and without further hand work except trimming. These plastic prototypes can be made to dupli-

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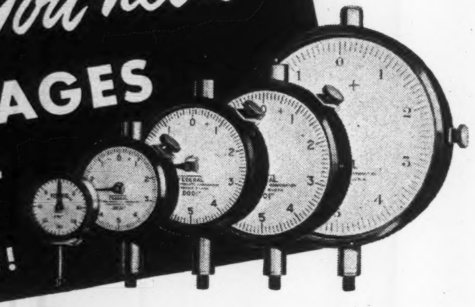
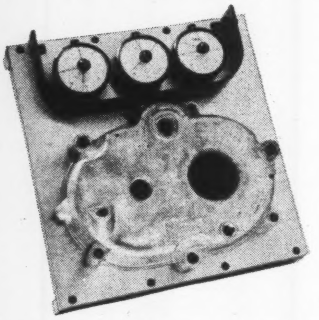
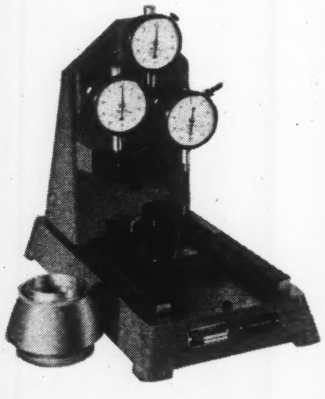


Dial Indicators for every gaging requirement—over 80 different models, ranges, sizes, graduations, styles.



Simultaneously checks the depth of three bosses on flange face of gear housing plate.



Checks height of two shoulders and depth of one groove of fuse body.

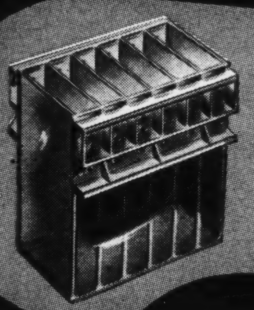
Concentricity of the center hole diameter, the inside diameter, three groove depths, an outside diameter — with the body diameter.

Dimensional gages are specialized tools: their design and construction requires the knowledge and experience of specialists. Tell us your gaging problem. Perhaps one of the 25,000 gage designs in our files will answer your needs or can be adapted to meet your requirements. Not only does our vast fund of gaging information save development time but it probably can provide you with the right gage at less cost than creating a wholly new gage.

Our engineers are accustomed to working with product designers and will gladly cooperate with you on your dimensional gaging requirements. For the right answer, quickly and confidentially, bring your special gaging problem to Federal and take advantage of our long experience in designing and building dimensional gages. Send full details and blueprints to Federal Products Corporation, 3010 Eddy Street, Providence 1, Rhode Island.

FEDERAL

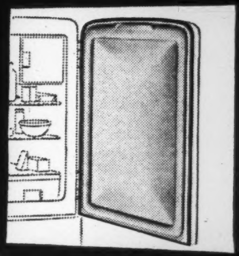
Largest manufacturer devoted exclusively to designing and manufacturing *all types* of DIMENSIONAL INDICATING GAGES



New

The FIRST successful one-piece Jet Battery Case

Strong, light (just 8⅔ lb.). Molded by "single-shot" injection on giant 300-oz. presses. Non-corrosive and unaffected by elements. Extreme toughness takes abuse.



Bigger

Inside door panel for Refrigerators

One of the biggest (31" x 48") moldings ever produced anywhere! No moisture distortion. Extreme dimensional stability. Allows use of more contours. Color molded in, stays in!

Better

Rich-appearing Air Conditioning Cabinets

Plenty of customer appeal in these expensive looking cabinets. Compression molded of phenolic in one piece on 2000-ton presses. Excellent stability.

and molded by GENERAL AMERICAN!

These three moldings are typical of the completeness of General American's facilities. Creative engineering—correct material selection—precision molding—painting and packing. General American's Plastics Division is your answer to single-responsibility, high quality molding. *Write for descriptive brochure.*

PLASTICS DIVISION
GENERAL AMERICAN TRANSPORTATION CORPORATION
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New York 17: 10 East 49th Street
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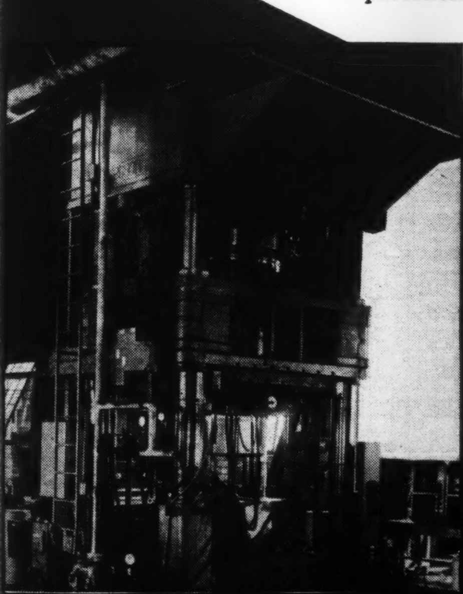


more men and machines to produce YOUR products of plastics better...

"Joe, who can make these small parts to our close 'specs'?"

"Torrington can, Tom. They have the experience and equipment to maintain precision tolerances on any quantity of small metal parts."

Small precision parts often take more production time than can be spared. That's why many leading manufacturers have turned over their parts problems to Torrington. Using the latest automatic and semi-automatic equipment, our Specialty Department produces hundreds of thousands of parts every day to the exacting specifications of hundreds of customers. These companies—some of them Torrington customers for over 40 years—have learned that they save both time and money when their small metal components are made by Torrington.

Why not send us a blueprint or sample of *your* small parts? We will quickly tell you how little it costs to have uniformly accurate components.

Typical Torrington-Made Parts

THE TORRINGTON COMPANY
Specialty Department
553 Field Street • Torrington, Conn.

Makers of
TORRINGTON NEEDLE BEARINGS

cate almost any part, whether it is a stamping, die casting, iron or steel casting, forging, rubber part, or whether such parts make up units like frames, engines, bodies, axles, transmissions, wheels, etc.

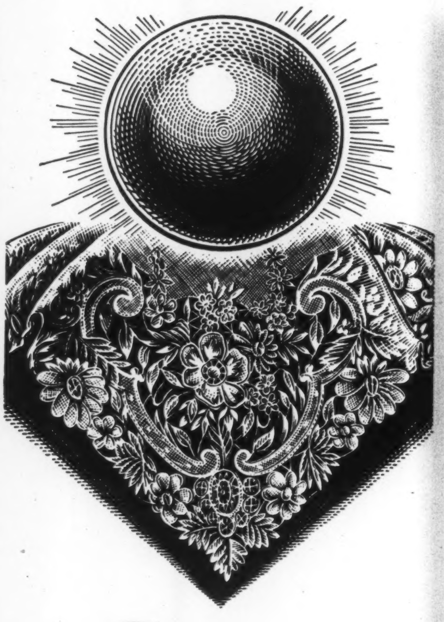
Plastic prototype study parts are light and easy to handle, can be carried easily to meetings and conferences where they will not scratch tables or cut a person in handling. One man can carry a complete automobile side assembly with no effort. Plastic parts can be reworked, patched, cemented, and altered into different designs. They are quickly and cheaply duplicated so that copies can be sent to groups quite remote from the original engineering meetings, and copies can be used for original records in the design evolution, for process engineers, material handling engineers, cost analysts and many others.

Versatile Properties

Material developments have been such that prototype parts of plastic are tough, resistant to severe bumps and abrasions, shatterproof, waterproof, stainproof, greaseproof, acid resistant, and have many other physical, chemical and electrical properties. Plastics can be molded, sawed, sheared, drilled, machined, sanded, sewed, cemented, polished, patched, reworked, metal coated, painted, plated, and treated in many additional ways in accordance with each requirement.

The most easily used form is sheets, in thicknesses of from less than 0.010-inch to over ¼-inch. These sheets are available in transparencies and in colors from a thin milk white to jet black through pastels and shades of colors which are quite advantageously used for contrast between different parts, and to follow a color pattern to indicate interchangeability and other points. The sheet plastics are readily formed over (and into) low-cost molds of the individual parts.

Plastics are also available in a liquid form, to which catalysts are added to solidify them into the degree of hardness wanted. Polyes-



Fine Belgium Lace

is distinguished from other lace because it is made with a single thread continuously worked into a beautiful delicate pattern.

Universal Precision Balls are distinguished from other balls because they conform to a simple pattern thru a rigid quality control system.

Where high speeds, silent operation and minimum torsional resistance are determining factors, Universal Balls are the best balls by test.

These are just a few sincere reasons why those who know precision balls best accept nothing less than Universal's high standard of quality.

Specify Universal Balls and your bearings will become literally Methuselahs when it comes to long life.

UNIVERSAL BALL CO.
PRECISION BALLS OF CHROME AND STAINLESS STEEL, BRONZE AND SPECIAL METALS.
WILLOW GROVE, Montgomery County, Pa.
Telephone, Willow Grove 1200

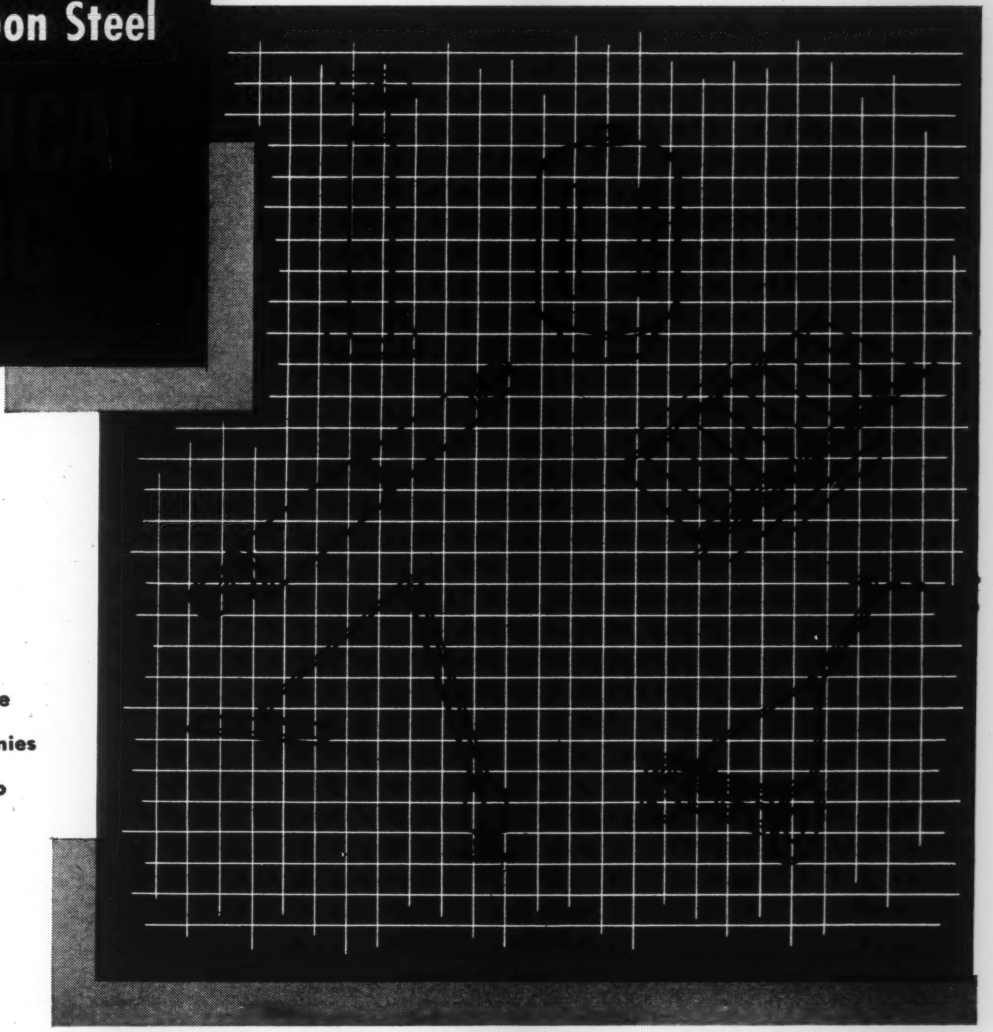
take a

CLOSER LOOK

at

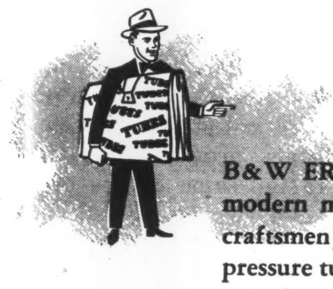
B&W ERW Carbon Steel

MECHANICAL TUBING



to

- ... **Simplify Product Design**
- ... **Improve Appearance**
- ... **Reduce Scrap Loss**
- ... **Speed Fabrication**
- ... **Save Final Finishing Time**
- ... **Secure Maximum Economies**
- ... **Obtain Higher Strength to Weight Ratio**



B&W ERW tubes are made on the same modern mills (and by the same skilled craftsmen) that produce B&W welded pressure tubes which have for many years met the exacting requirements of boilers and other heat transfer apparatus. This inherent standard of excellence assures you the finest welded tubing to make hollow structural and machined parts. Write for Bulletin TB 333, a thrifty little booklet filled with cost-saving details. Or call in Mr. Tubes, your B&W Tube Representative, to help you match tubing economies and production efficiency.

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION

General Offices & Plants
Beaver Falls, Pa.—Seamless Tubing; Welded Stainless Steel Tubing
Alliance, Ohio—Welded Carbon Steel Tubing

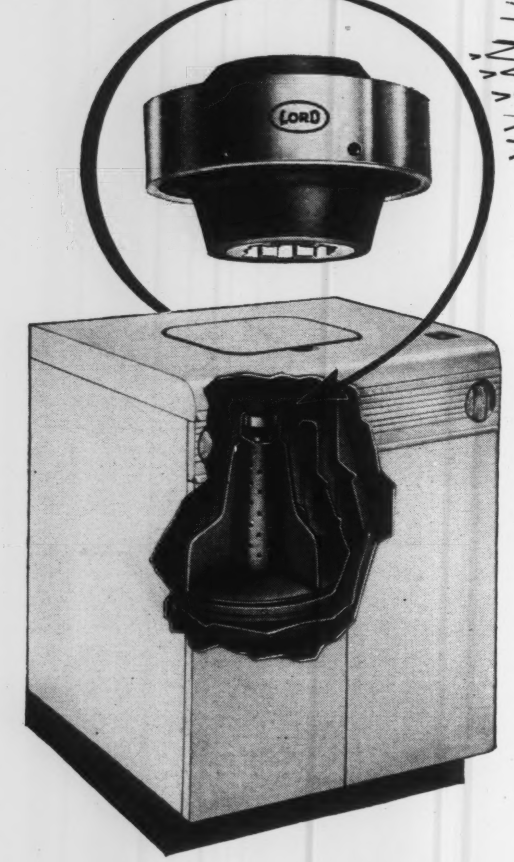
Sales Offices: Beaver Falls, Pa. • Boston 16, Mass. • Chicago 3, Ill. • Cleveland 14, Ohio • Denver 1, Colo. • Detroit 26, Mich. • Houston 19, Texas • Los Angeles 17, Cal. • New York 16, N. Y. • Philadelphia 2, Pa. • St. Louis 1, Mo. • San Francisco 3, Cal. • Syracuse 2, N. Y. • Toronto, Ontario • Tulsa 3, Okla.

B&W
SEAMLESS and WELDED
TUBES

TA-1689M

Smooth, Quiet Operation Wins Customer Acceptance

for BLACKSTONE CORPORATION



LORD Bonded-Rubber Mountings used in basic design help to increase sales for leading appliance manufacturers. Inherent Vibration and Shock are actually "designed out" of the appliance, resulting in smooth operation and longer service life. For instance, the famous Blackstone Automatic Washer does its work quietly and efficiently with the "spin dry" basket mounted on the Lord bonded-rubber flexible mounting. This Lord bonded-rubber flexible mounting compensates for unbalanced loading of the "spin dryer" during the clothes-drying cycle. This is another of many examples in which Lord engineering experience and precision manufacturing technique combine to advantage in basic design to speed up and increase end product sales in highly competitive markets. Consider increasing consumer preference for your product by using Lord vibration and shock control mountings.

BURBANK, CALIFORNIA
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PHILADELPHIA 7, PENNSYLVANIA
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DAYTON 2, OHIO
238 Lafayette Street

DETROIT 2, MICHIGAN
7310 Woodward Ave.

NEW YORK 16, NEW YORK
280 Madison Avenue

CHICAGO 11, ILLINOIS
520 N. Michigan Ave.

ERIE, PENNSYLVANIA
1635 West 12th Street

LORD MANUFACTURING COMPANY • ERIE, PA.

LORD BONDED RUBBER

HEADQUARTERS FOR VIBRATION CONTROL

ter and phenolic resins reinforced with Fiberglas are used to make parts which are even stronger than steel, are dimensionally stable, and so accurate that they can be used to build checking fixtures.

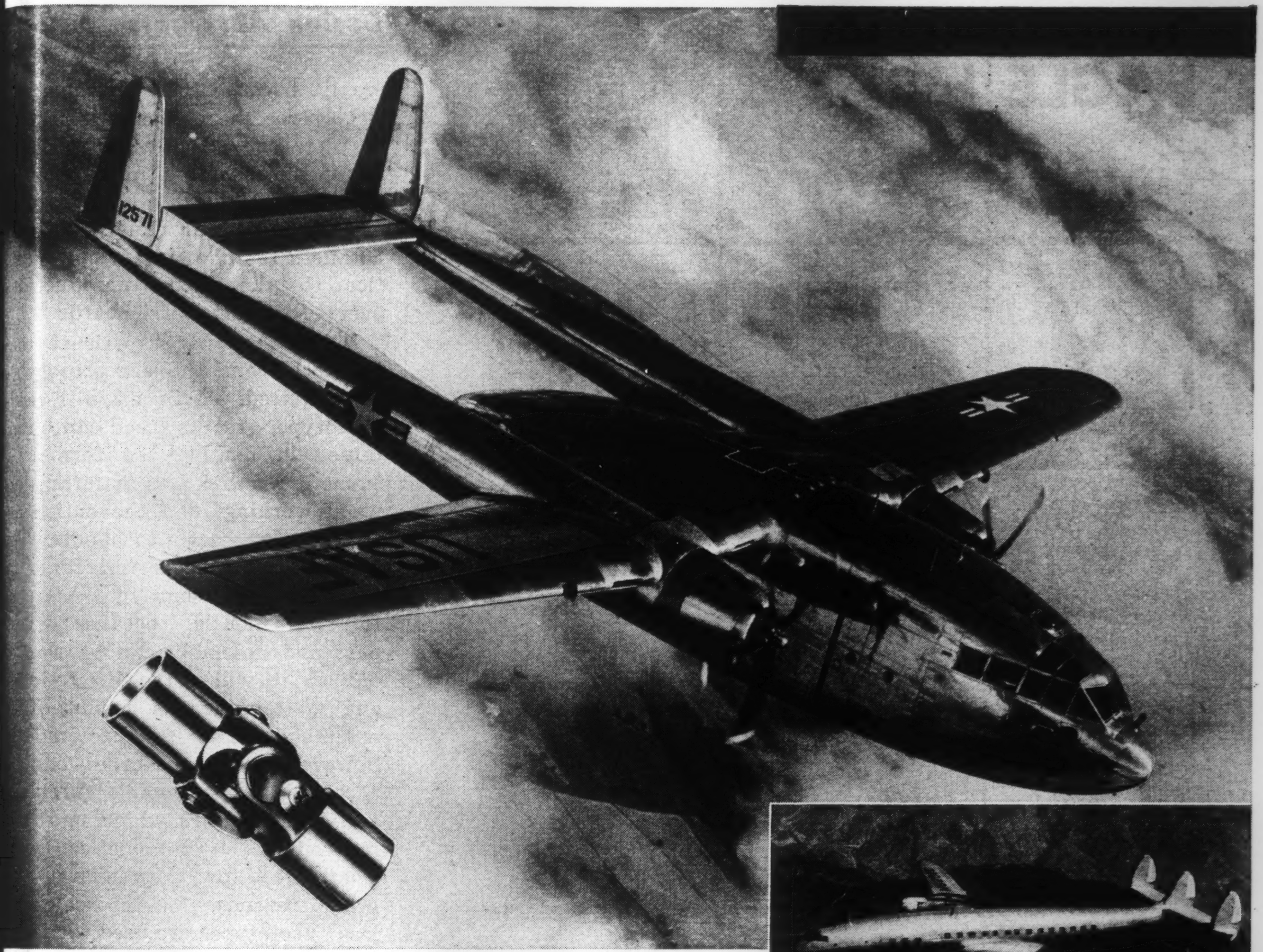
Liquid plastics are also used to great advantage in making master molds and dies over which not only plastic parts, but steel, aluminum and other metal parts can be made. These plastic dies and forms are not only extremely accurate but are tough and stable, as well as durable, for a period of years. The liquid plastics are also used to cast and mold parts to represent prototypes of castings, forgings, die castings, extrusions, and several other forms of materials.

Drafting Minimized

Since plastic prototype models can be made much more quickly than detailed parts can be drawn or dimensioned, it is a logical step for designers to take advantage of plastic study models as a medium of development from rough layouts and drafts without detailing. Parts can be fashioned so quickly, and changed so easily, that an evolution into three-dimension product designing can be readily achieved to replace the flat, laborious "thinking on paper" as at present.

Designers can have these plastic parts Stress-coated and subjected to torsional and beam loads to detect stress patterns from deflections. It has been found that Stress-coated plastic parts will display identical stress characteristics with steel, provided they are limited to the same degree of deflection that would be encountered with steel parts. Stress-coating can be useful to detect weak areas and fracture points early enough to guide the engineer in altering his design to obtain maximum stress values.

Also, after utilizing plastic development models to arrive at the accepted advance design, it is extremely advantageous to turn these plastic models of the accepted design over to detailers to complete the engineering drawings. This reduces drafting time consid-



FOR PASSENGER PLANES
136

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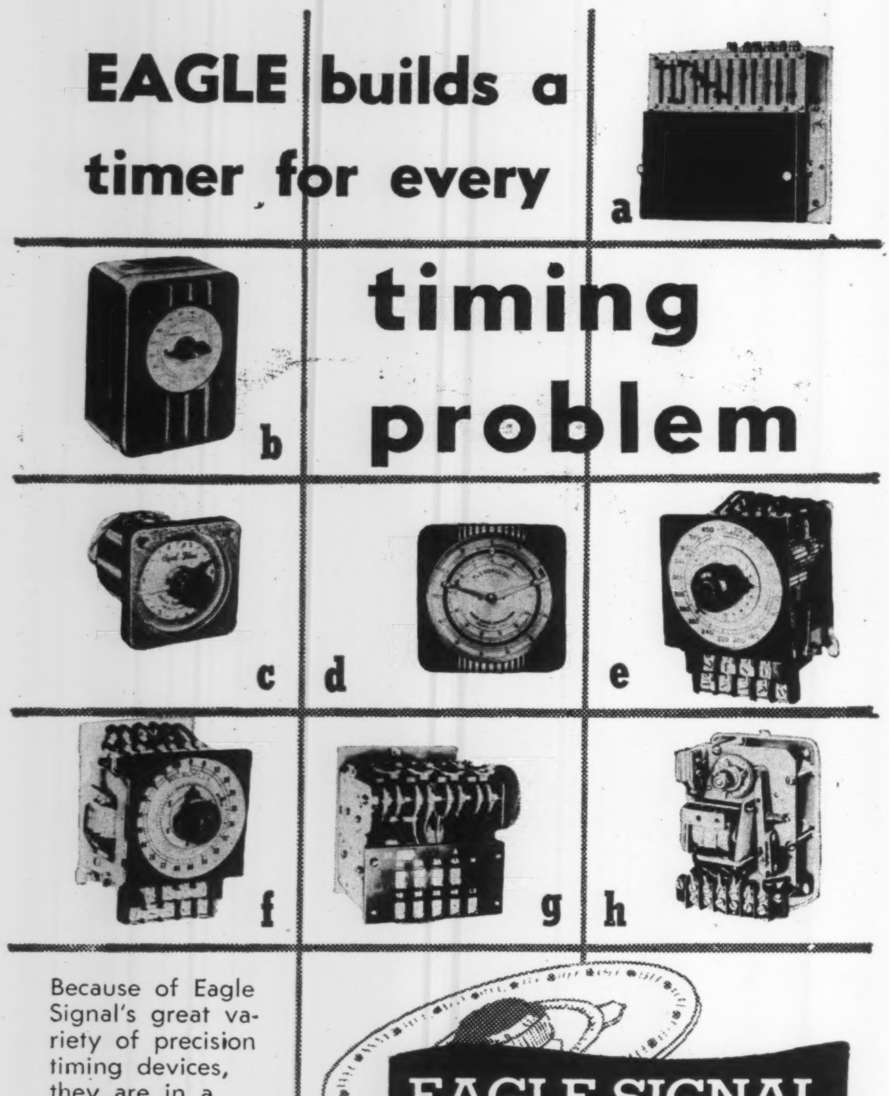


EAGLE builds a timer for every timing problem

Because of Eagle Signal's great variety of precision timing devices, they are in a position to suggest the exact timer required for your individual industrial problem. Let Eagle help speed up production and save countless man hours for you. Write for Bulletin 340.

EAGLE SIGNAL
Industrial Timers
EAGLE SIGNAL CORPORATION MOLINE, ILL.

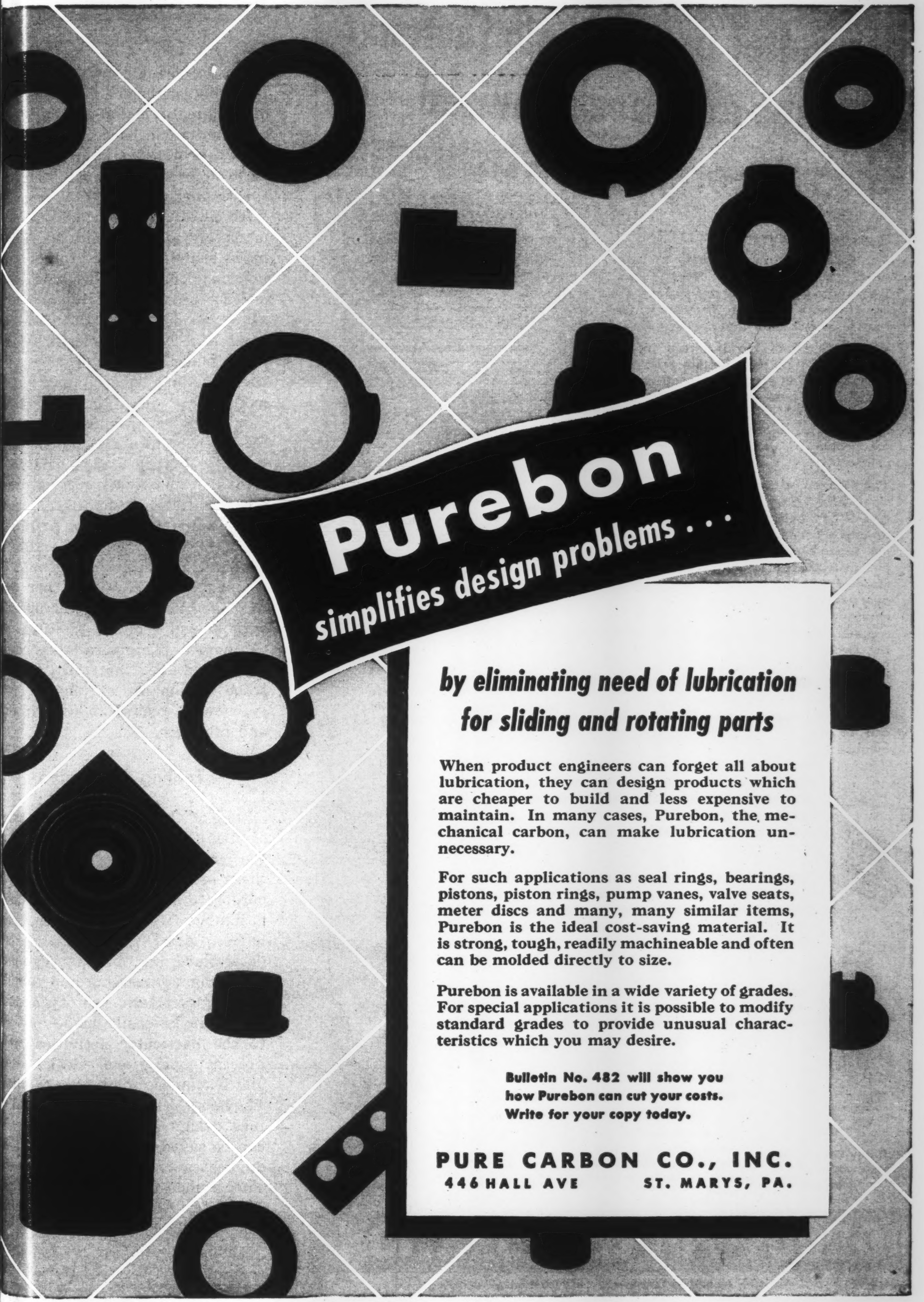
- a. **MULTIFLEX** (Multiple Circuit) Reset Timer . . . closes and opens one or more circuits during a time interval started by push button, limit switch, etc.
- b. **DURAFLEX** Reset Timer . . . holds circuit closed for preset time after "start" button is pressed.
- c. **CYCL-FLEX** Reset Timer . . . opens or closes a circuit after an adjustable time period.
- d. **FLEXOPULSE** Repeat Cycl Timer . . . closes and opens a contact repeatedly as long as synchronous motor is energized.
- e. **MICROFLEX** Reset Counter . . . opens or closes a contact after a preset number of impulses.
- f. **MICROFLEX** Reset Timer . . . opens or closes a circuit after an adjustable time period.
- g. **POLYPULSE** (Multiple Circuit) Program Timer . . . closes or opens one or more circuits in a repeating series of operations.
- h. **TIMOFLEX** . . . a time delay relay for opening or closing a circuit.
- i. **POLYFLEX** (Multiple Circuit) Reset Timer . . . closes or opens one or more circuits during a time interval started by push button, limit switch, etc.
- j. **MANUFLEX** Timer . . . used where a device is turned "on" manually, runs a selected time and stops automatically.

erably, because the draftsmen can clearly see the objects which they are detailing. While previously it has been, of course, impractical to take large clay models of accepted designs over to drafting boards for detailers to follow, it is now practical to take plastic reproductions over to the detailers' boards.

It has been our experience that both scale and full-size prototypes are required. With a 3/8-th scale prototype, greater speed can be attained in making the forms because it requires less material, less wood working, and the entire assemblies are easier to handle. The 3/8-th scale models will show up the same problems in design as full-size models, because every part and assembly can be worked out so it will serve its function and go together as a unit of an assembly. The full-size models, however, show true conditions for accessibility, stamping problems and other factors which might be misleading on a smaller scale. Therefore, for convenience and other reasons, 3/8-th scale (or less) prototypes are used for faster overall development work of whole assemblies, while full-size prototypes are used for local area study for tooling and processing, and for actual trials.

Preliminary Appraisals

Preliminary preparations for manufacturing, starting with too estimates, have been customarily made from plaster, clay or wood models, special mockups and drafts. These preliminaries are usually based on general exterior appearance and the association of previous cost history for the major parts, plus combined experience and "know-how" to determine the tooling differences between the new and the old designs. Inasmuch as it is practical to make a few plastic parts for outer appearance for styling uses, it is logical to go further and show, for manufacturing review, the structural design of all parts, subassemblies and major assemblies as they are made up of stampings, forgings, castings, and the like.



Purebon

simplifies design problems . . .

by eliminating need of lubrication for sliding and rotating parts

When product engineers can forget all about lubrication, they can design products which are cheaper to build and less expensive to maintain. In many cases, Purebon, the mechanical carbon, can make lubrication unnecessary.

For such applications as seal rings, bearings, pistons, piston rings, pump vanes, valve seats, meter discs and many, many similar items, Purebon is the ideal cost-saving material. It is strong, tough, readily machineable and often can be molded directly to size.

Purebon is available in a wide variety of grades. For special applications it is possible to modify standard grades to provide unusual characteristics which you may desire.

Bulletin No. 482 will show you
how Purebon can cut your costs.
Write for your copy today.

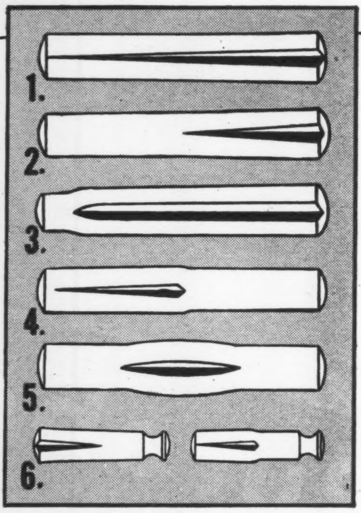
PURE CARBON CO., INC.
446 HALL AVE ST. MARYS, PA.

No better press fit pin fastener has ever been devised than the original GROOV-PIN

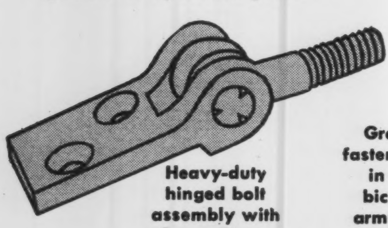
The Groov-Pin is primarily a cylindrical pin cut from bar or coil stock. Longitudinal grooves are rolled or pressed into the body to deform the stock within controlled standard limits.

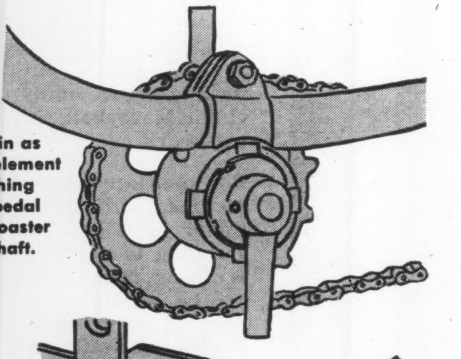
When the Groov-Pin is forced into a drilled hole of correct diameter, the constraining action of the hole wall causes the displaced material to flow back and make a locking fit within its elastic range. Resiliency of the pin stock makes it practicable to use the same pin repeatedly.

The Groov-Pin is simple in design, efficient, economical both in price and in cost of application, and it is versatile in its uses. This combination of advantages has never been surpassed by any other pin fastening. It is true even though Groov-Pins have been in use for over a quarter-century, essentially in their present form from the beginning. Like the common pin or nail the original design of the Groov-Pin was fundamentally perfect. Therefore, improvement has been impossible. Groov-Pins are assembled in straight drilled holes. No tapping, reaming, peening or milling are required. They can be driven by hand hammer, air cylinder or hydraulic press.

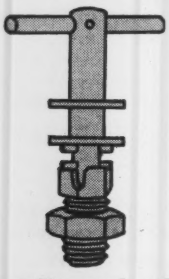


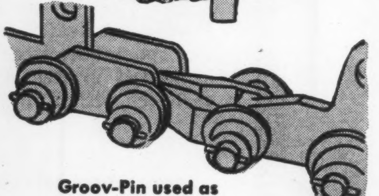
1. Full length taper Groov-Pin.
2. Half length taper Groov-Pin.
3. Full length parallel Groov-Pin.
4. Half length reverse taper Groov-Pin.
5. Center Groov-Pin.
6. Half length taper and reverse taper Groov-Pin with annular grooves for spring retention.


Heavy-duty hinged bolt assembly with Groov-Pin as hinge pin.


Groov-Pin as fastening element in attaching bicycle pedal arms to coaster brake shaft.

Groov-Pin used as cross pin in stud of cowling fastener.


Groov-Pins used as locating and stop pin and for locking handle in pressure relief valve stem.


Groov-Pin used as heavy duty cotters on heavy chain links.

GROOV-PIN CORPORATION

1129 Hendricks Causeway, Ridgefield, New Jersey

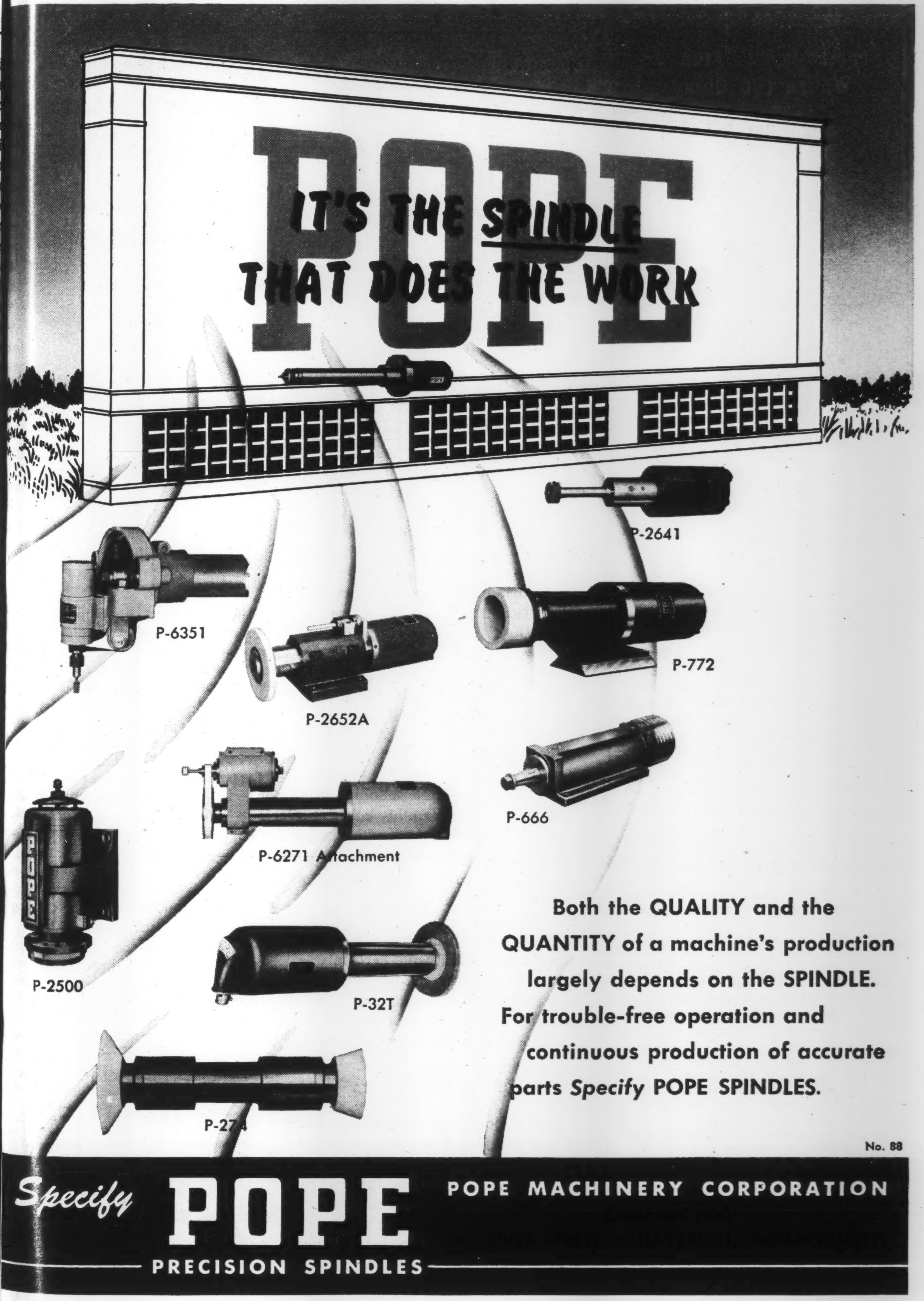
Design Abstracts

At the same time these plast parts are being studied by man facturing engineers for acceptanc of design for manufacturing, com plete units can be made quickly i plastic prototypes showing all th major parts so a much more ac curate cost analysis can be mad With plastic models fashioned im mediately after layouts have bee made, manufacturing problems ca be considered parallel with eng neering product design, instead o after models, tools, dies and fix tures have been completed, or eve parts made. It has been our ex perience that when plastic stud models are used in discussion new floods of ideas are contribute by both engineering and manufac turing personnel who would no ordinarily have contributed thes ideas until they had seen meta parts much later on in tooling o production. It would be folly t design a product which could no be manufactured with either pres ent facilities and equipment, o with known vendors' facilities an equipment. This possibility can b eliminated in the early desig stage by looking at plastic proto types with regard to known tool and facilities.

Tooling Facilitated

One of the strategic advantage of using plastic for prototypes i the ease and speed with whic these parts can be reworked to in corporate suggestions and counter designs of manufacturing engi neers. After the design is onc determined, and manufacturing en gineering (processing and tooling can begin, plastic prototype dupli cates can be easily made and sen to the particular activities whic process operations, design tool and machines, or prepare facilities Thousands of hours of tool and fix ture design and construction tim can be saved by using these plasti duplicates to work from. Tooling can be done with little fear of ma jor design changes, which by thi time should be negligible.

Modern industry is constantly searching for better materials, bet ter tools, better facilities, and bet


POPE
IT'S THE SPINDLE
THAT DOES THE WORK
P-2641
P-6351
P-772
P-2652A
P-666
P-6271 Attachment
P-2500
P-32T
P-274

Both the QUALITY and the
QUANTITY of a machine's production
largely depends on the SPINDLE.
For trouble-free operation and
continuous production of accurate
parts *Specify* POPE SPINDLES.

No. 88

Specify **POPE**
PRECISION SPINDLES

POPE MACHINERY CORPORATION
Established 1920
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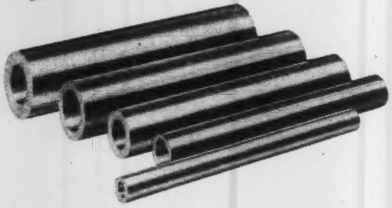
Promet Bars Stand Up
Where the Going
Is Tough!

PROMET
THE *Engineered* BRONZE

CORED & SOLID
BRONZE BAR STOCK



Made from Promet No. 6, an outstanding leaded bearing bronze noted for its free machining properties. Unbelievably great resistance to heat and wear. Will not burn, seize, pound out.

PROMET'S HIGH SAFETY FACTOR IS YOUR INSURANCE AGAINST BEARING FAILURE!

Tougher, harder and stronger, it resists shock loads and withstands high compressive forces and will not cut, or stick to the shaft under ordinary operating conditions. There is no seizing, no scoring—just smooth, quiet operation. Will not powder under the most severe conditions of service. When lubrication fails temporarily, Promet carries on safely until proper lubrication can be restored, affording protection against production shutdowns.

PROMET FULLY MACHINED BARS SAVE YOU TIME, TOOLS AND MONEY!

Completely precision machined inside, outside and on the ends, yet sufficient stock remains for the finishing cut. Can be machined at speeds of more than 500 feet per minute—more than double those of phosphor bronzes. This complete machining insures you against subsurface defects sometimes found in rough cast bars. A considerable amount of metal has already been removed—metal which you would be purchasing if you used rough bars. Every bar is absolutely concentric.

Available round, hexagon and square, in 13-inch lengths, rough cast.

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of longer, superior service and lower maintenance cost.

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Our competent design and engineering staff will be glad to assist you in solving your special bearing problems. Send today for free literature.

THE AMERICAN CRUCIBLE PRODUCTS CO.
1321 Oberlin Avenue Lorain, Ohio

Please send free literature on Promet Cored and Solid Bronze Bar Stock

NAME ....
FIRM ....
STREET ....
CITY & STATE ....

ter ways of doing things. The widening use of plastics as an aid to designers is one of them. What is done with them is limited only by our imaginations and hard work.

From a paper entitled "Plastic Prototypes Revolutionize Preparation for Manufacture" presented at the SAE Summer Meeting in Atlantic City, N. J., June 1952.

Electronics for the Office

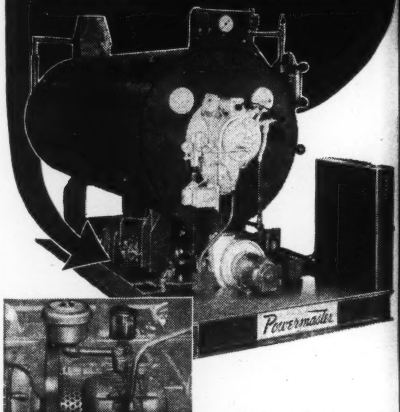
By John S. Coleman
President
Burroughs Adding Machine Co.
Detroit, Mich.

IN PERFORMING their tasks, electronic computers have demonstrated an inherent capacity to carry out several very human-sounding functions. Under certain conditions, they could compare and then select. Under certain circumstances, they could remember the information gleaned from one calculation and use it to advantage in another. No one claimed that they were human. It was well known that they could perform these functions only to the extent that their human creator had foreseen all procedures and all alternatives and provided for them in their design. Still, it was obvious from the first that machines of such capabilities could hold momentous implications for mankind.

Thus it was at once apparent, from the nature of the problems they solved, that these machines gave promise of an even wider significance—a significance of which office application was certainly a part. There seemed little reason why such things should not be put to work to solve one of the greatest problems created by our modern business system—the rising volume and complexity of office work.

The majority of electronic computers completed to date were designed, not for business use, but for scientific use. Improvements, new ideas for business adaptation are coming along all the time; but for all practical purposes, we are still working with essentially the same computer components that

GAST rotary air compressors ATOMIZE FUEL OIL UNIFORMLY for "Powermaster" Steam Generators



Left — Gast Model 2065 used on 100 H.P. unit.

PROBLEM: Select a compressor to supply uniform, pulseless air volume for atomizing fuel oil in the combustion chamber of Orr & Sembower "Powermaster" Boilers.

SOLUTION: Three sizes of Gast Rotary Air Compressors proved excellent for boilers of 50, 100 and 150 H.P. Gast Rotary Vane Design delivers positive, pulseless pressures from 18 to 22 psi and displacements to 22 cfm — *without* a bulky pressure tank.

RESULT: Positive air volume *pulverizes every droplet of fuel oil.* Long, trouble-free performance results from ball-bearing compressors with automatic lubricator, intake filter, cooling fins and fans.

ONCE AGAIN you can see how Gast Rotaries — plus concentrated experience with air power, low vacuum and pressure — helped solve a specific problem. Have you considered the advantages of Gast Rotaries on your product? Write us, outlining your problem — you'll receive prompt cooperation. "Air may be your Answer!"

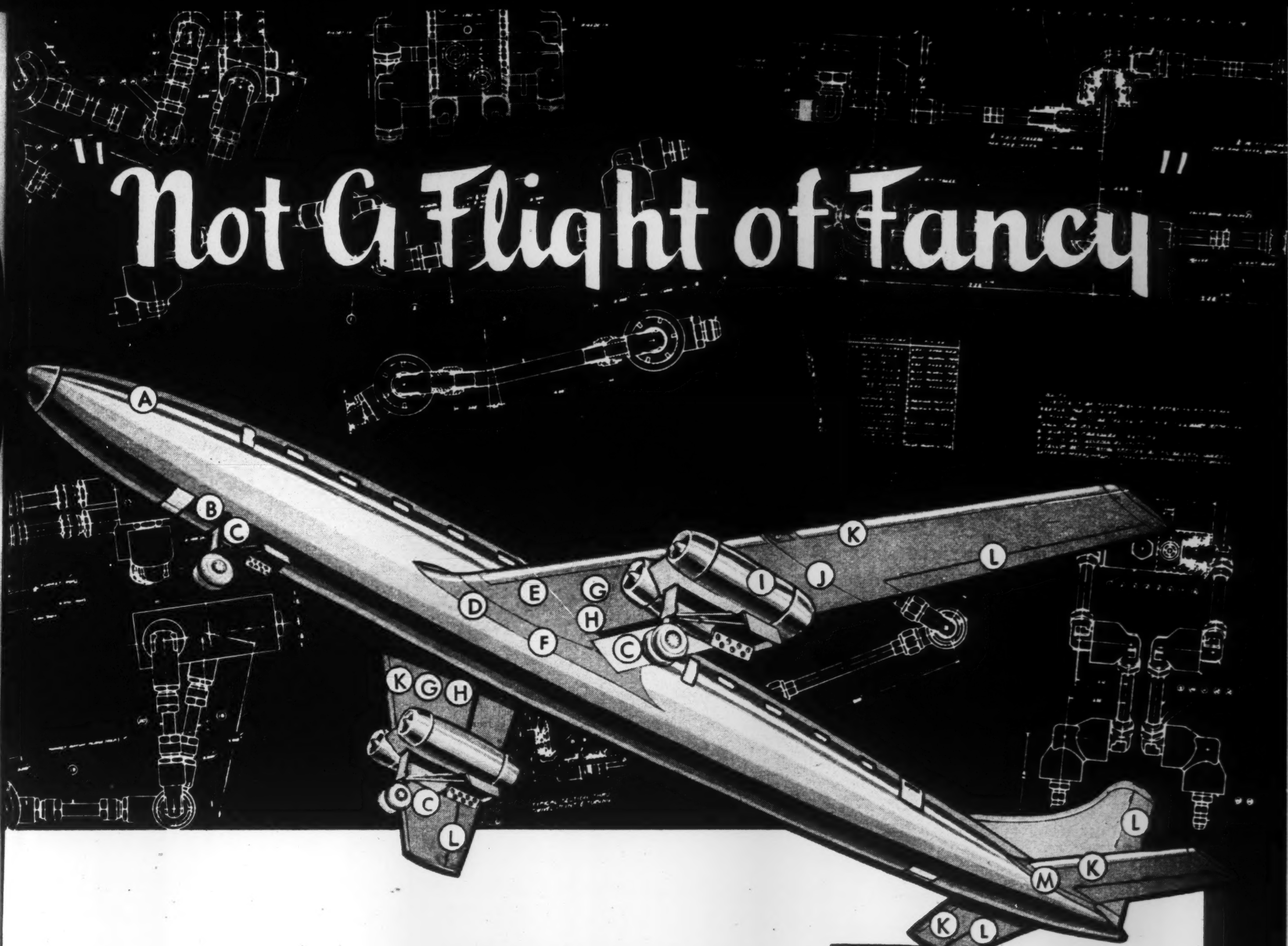
Gast Application Ideas Booklet — showing 26 design problems solved — sent upon request.

see our CATALOG in SWEET'S FILE for PRODUCT DESIGNERS

Original Equipment Manufacturers
for Over 30 Years

GAST ROTARY
AIR MOTORS · COMPRESSORS · VACUUM PUMP
(TO THREE H.P.) (TO 30 LBS.) (TO 28 INCHES)
GAST MANUFACTURING CORP., 107 Hinkley St., Benton Harbor, Mi

"Not A Flight of Fancy"



HERE ARE WAYS **CHIKSAN** CAN HELP AIRFRAME MANUFACTURERS

The airplane shown here is not an actual picture of any one plane. Rather, it is a composite to show some of the varied ways in which Chiksan planning can help the airframe manufacturer do a better job.

Fuel, oil, water, air and oxygen all find dependable, safe, uninterrupted flow through Chiksan aero-hydraulic swivel joints and assemblies.

CHECK THESE APPLICATIONS IN YOUR BLUEPRINTS:

A. Refueling boom assembly
B. Steering control mechanism
C. Brake system
D. Spoiler actuating mechanism
E. Fuel and oil lines
F. Adjustable sweep-back system
G. Emergency dump chute
H. Flap actuating system
I. Power-plant fuel and oil lines
J. Wing fold
K. De-icing system
L. Power control system
M. Stabilizer trim

The Flow of Enterprise Relies on

CHIKSAN

Ball-Bearing Swivel Joints

REPRESENTATIVES IN PRINCIPAL CITIES

A few of the many Chiksan aero-hydraulic swivel joints made for pressures ranging from 1000 to 3000 psi.

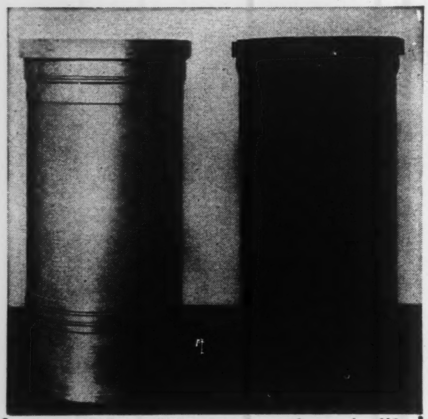
AMERICAN CHEMICAL PAINT COMPANY

AMBLER CHEMICALS ACP PROCESSES **PENNA.**

Technical Service Data Sheet
Subject: PROTECTING FRICTION SURFACES WITH THERMOIL GRANODINE®

INTRODUCTION

Fabricators and product designers, particularly in the automotive field, are aware that even highly polished surfaces under friction weld, gall and score. One of the most inexpensive and practical methods of preventing this is to coat the metal to prevent metal-to-metal contact. With cast iron or steel, the "Thermoil-Granodine" manganese-iron phosphate coating provides a wear-resistant layer of unusual effectiveness.



Thermoil-Granodizing greatly prolongs the life of parts subject to friction. It protects the surface of products like the diesel engine liners shown above and the many moving parts of automobiles and other machines. "Thermoil-Granodine" with its remarkable lubricating properties is particularly valuable in these and similar applications because of its ability to retain oil and maintain lubrication under high pressures and high velocities. This ACP wear-proofing chemical not only permits rapid break-in without scoring, scuffing and welding but also reduces subsequent wear on friction parts.

"THERMOIL-GRANODINE" PROTECTS RUBBING PARTS

Thermoil-Granodizing removes "fuzz" from ferrous metal friction surfaces and produces a coating of non-metallic, water-insoluble manganese-iron phosphate crystals which soak up and hold oil as bare untreated metal cannot do. The oiled crystalline "Thermoil-Granodine" coating on piston rings, pistons, cylinders, cylinder liners, cranks, cam-shafts, gears, tappets, valves, spiders and other rubbing parts, allows safe break-in operation, eliminates metal-to-metal contact, maintains lubrication and reduces the danger of scuffing, scoring, welding, galling and tearing of the metal. The work to be protectively treated is merely Thermoil-Granodized and oiled, usually with a soluble oil.

"THERMOIL-GRANODINE" MEETS THESE SPECIFICATIONS

SPECIFICATION NUMBER	SPECIFICATION TITLE
MIL-C-16232 Type I	Coatings — phosphate; oiled, slushed, or waxed (for ferrous metal surfaces) and phosphate treating compounds.
AN-F-20 (See also U.S.A. 3-213)	Finishes, for electronic equipment.
U.S.A. 57-0-2C Type II, Class A	Finishes, protective, for iron and steel parts.
U.S.A. 51-70-1 Finish 22.02, Class A	Painting and finishing of fire control instruments; general specification for
M-364	Navy aeronautical process specification for compound phosphate rust-proofing process.

CHEMICALS ACP PROCESSES

WRITE FOR FURTHER INFORMATION ON "THERMOIL-GRANODINE" AND ON YOUR OWN METAL PROTECTION PROBLEMS.

CHEMICALS ACP PROCESSES

were developed for the solution o mathematical problems. True, at many points the underlying principles of both types of work are similar. But there are important differences, and these have given rise to a legion of provoking technological problems.

Computations Differ

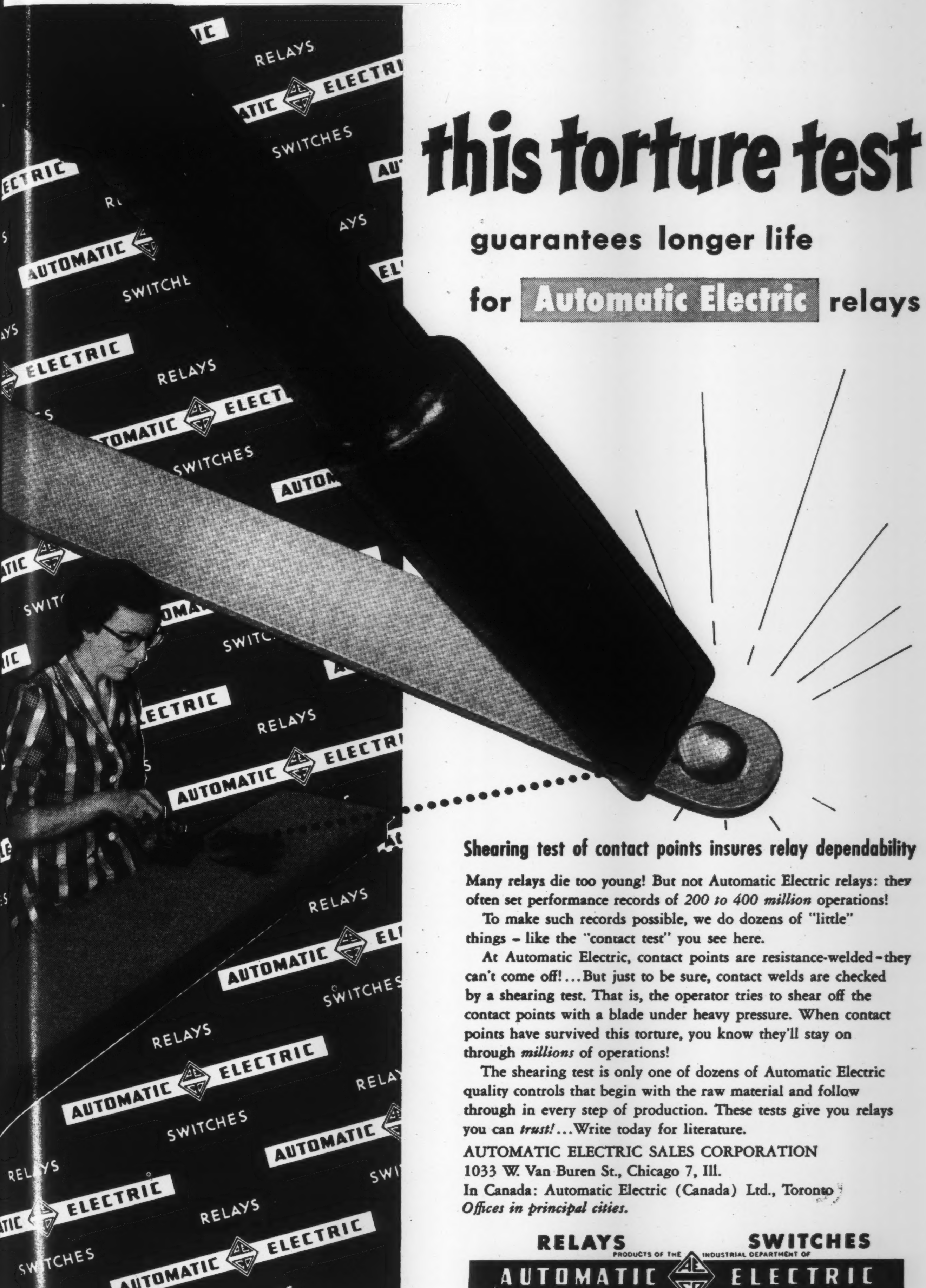
The mathematics of science and engineering involve a large amount of computation sandwiched between short questions and short answers. So it follows that the electronic computer, with its relatively simple input and output mechanizations, and its larger, more complicated internal components, is ideally designed for this kind of work.

Now, if we think of almost any clerical duties, it will be clear that the proportions are reversed. The figuring work incidental to a sale is neither lengthy nor complicated. It is largely a matter of simple arithmetic. The headaches occur, first in gathering from a number of sources the information on which the figuring depends; secondly, in entering the results on all the necessary records. So here we see that the volume and the complexity are concentrated in handling the questions and answers—not in the computations in between. If the electric computer is to be adapted to clerical use, therefore, the input and output mechanisms must be greatly amplified, and the computing mechanism appropriately cut down in size—and in cost.

Machines Have Own Lingo

This input-output question is rather a touchy one—even in mathematical work. Unfortunately, none of these machines has yet mastered our mother tongue; they deal in a strange lingo of signs and symbols that has to be recorded on magnetic tape, or some similar medium. This requires a mechanical means of coding input instructions and data, and decoding the output answers.

While the internal components



this torture test

guarantees longer life for Automatic Electric relays

Shearing test of contact points insures relay dependability

Many relays die too young! But not Automatic Electric relays: they often set performance records of *200 to 400 million* operations!

To make such records possible, we do dozens of "little" things - like the "contact test" you see here.

At Automatic Electric, contact points are resistance-welded - they can't come off!...But just to be sure, contact welds are checked by a shearing test. That is, the operator tries to shear off the contact points with a blade under heavy pressure. When contact points have survived this torture, you know they'll stay on through *millions* of operations!

The shearing test is only one of dozens of Automatic Electric quality controls that begin with the raw material and follow through in every step of production. These tests give you relays you can *trust!*...Write today for literature.

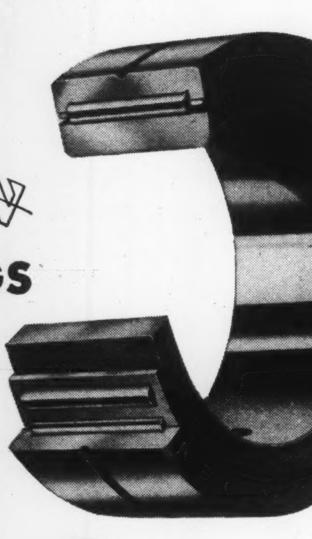
AUTOMATIC ELECTRIC SALES CORPORATION
1033 W. Van Buren St., Chicago 7, Ill.
In Canada: Automatic Electric (Canada) Ltd., Toronto
Offices in principal cities.

RELAYS PRODUCTS OF THE INDUSTRIAL DEPARTMENT OF **SWITCHES**
AUTOMATIC ELECTRIC
CHICAGO

RBC

PITCHLIGN

ROLLER BEARINGS

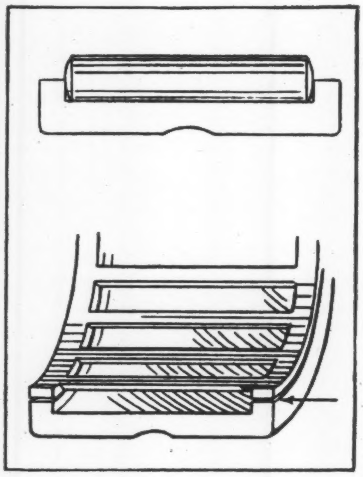


...have Integral Flanges

Rollers are located axially by direct contact with the flanges which present a continuous surface to the ends of the rollers. As a result, it is impossible to have end thrust against the cage.

Integral flanges support the free-floating cage which does not ride the rollers, but acts only to align them at their pitch circle. Flanges serve also to retain lubricant.

PITCHLIGN is interchangeable with precision needle bearings. Get all the facts!



PITCHLIGN
TRADE MARK
ROLLER BEARINGS

GET THE FACTS!

Write Today

Ask for Bulletin SF-266

ROLLER BEARING COMPANY OF AMERICA • TRENTON, N. J.

do their part with incredible spee the input and output processes a both exasperatingly slow. It's little like the old Indian definitio of skiing: "Climb big hill — whoosh—then walk a mile." Fro a business viewpoint, we gain littl by the "whoosh." Our problem and our expense are centered in th big hill and the mile walk—a larg volume of sales, perhaps all occurring simultaneously, all requiring, at one end, reference to a number of different records; all requiring at the other, the entering o the transaction in another assorment of records.

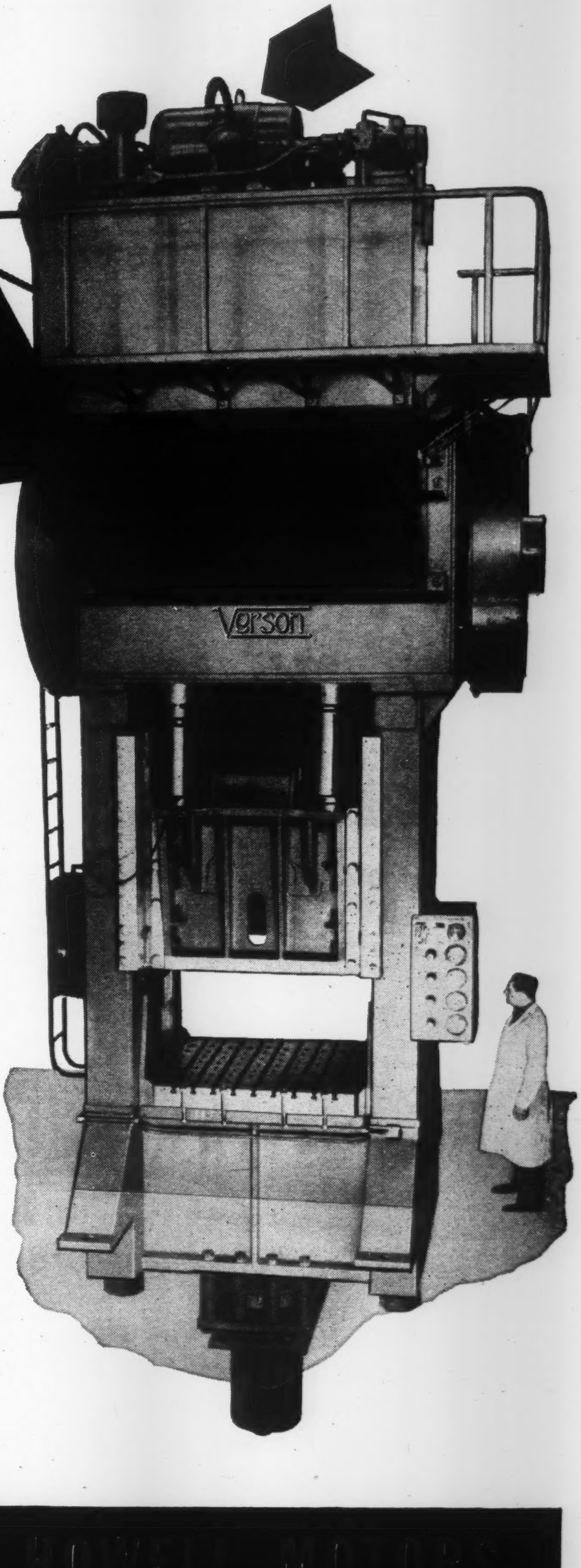
Computers Can't Think

The successful operation of a electronic computer depends on design which provides for *all* prcedures and *all* alternatives. W must remember that it has n imagination, no common sense. I a computer could jump, it migh easily hurdle a skyscraper, only t balk at a toadstool—unless it ha explicit instructions for both. S you cannot say, as you would to human being, "Look—here's th general idea. Here are a few cocrete examples. Now, use you own judgment." The electroni computer has no judgment. Th first variation from instructions however picayune, will throw i off.

Now, inherent in all business i the necessity for random access Customers will not line up in alphabetical order. Their preferences, their buying habits, thei paying habits can never be regimented or completely foreseen Hundreds of gnat-sized annoyance form part of the daily routine o any business. They cannot b fully anticipated. They requir only two things, really; a littl imagination, plus a little commo sense.

This phase of business operatio is simply not one of those whic lends itself to machine applicatio I do not say that a machine canno be made to do, say 90 per cent o it. It can. But only under highl specialized conditions would it b able to supersede human effor

Machine with a
POWERHOUSE
PUNCH!



In one mighty blow, this giant 850-ton, double-action, deep-drawing Verson Allsteel press forms an intricate automobile part.

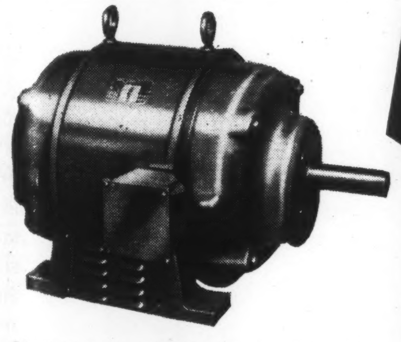
Multiply this by seven strokes a minute, 3 shifts a day, seven days a week and you have a rugged operating schedule . . . one which the Howell motors that power this fine press take right in stride.

Howell engineers worked closely with this manufacturer to select the *right* motor for each job. The main drive motor is a Howell 50 H.P. high slip, high torque motor designed specially for punch press work. The self-adjusting blankholder is driven by a hydraulic pump, powered by a 50 H.P. Howell motor. A 20 H.P. Howell motor operates another hydraulic drive.

Howell will devote the same care and attention to your electric motor problems and needs. With this cooperation and Howell quality, you're assured of motors that will stand up under the heaviest production load over long periods without interruption.

May we help you?

HOWELL ELECTRIC MOTORS COMPANY
Howell, Michigan



Howell Type F Motor. A high slip, high torque motor designed for punching and shearing operations. Sizes ½ to 200 H.P. in open frames; ½ to 125 H.P. in enclosed frames.

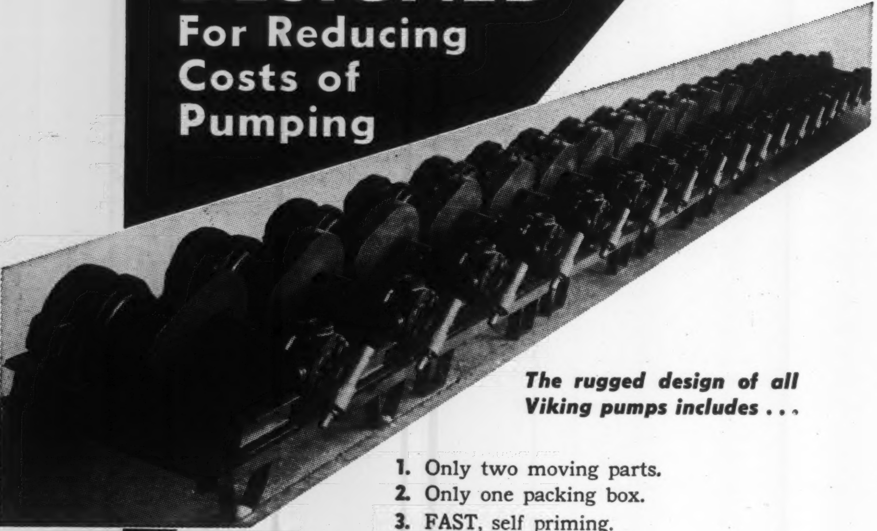
HOWELL
Red Band
MOTORS
®

HOWELL MOTORS

HOWELL ELECTRIC MOTORS CO., HOWELL, MICH.

Precision-built industrial motors since 1915

DESIGNED
For Reducing
Costs of
Pumping



The rugged design of all Viking pumps includes . . .

1. Only two moving parts.
2. Only one packing box.
3. FAST, self priming.
4. Smooth, even discharge.
5. Adaptation for handling either viscous or thin liquids.
6. Low power requirements.

by VIKING

Lower your pumping costs. Start with bulletin 52SH. Gladly sent on request.

Viking PUMP COMPANY
Cedar Falls, Iowa

ELECTRAN
TRANSFORMERS

★ TRANSFORMERS
★ SATURABLE REACTORS
★ ELECTRONIC DEVICES

Specialists in SMALL quantities of custom built transformers from milliwatts to 50 KVA, single or polyphase— designed and manufactured to best meet your exact requirements.

Each Electran Transformer is built to the highest standards of quality and precision. There is no "second" grade at Electran.

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completely. And even here, the possibility of such a machine gives no assurance of its practicality, especially from the point of view of cost.

By the same token, there are a number of business operations for which all factors are known in advance, and where the volume of work is very large. It is here—once we have overcome this input-output problem and others of a technological nature — that the speed and accuracy of electronic mechanisms could be of real value.

Up to now, a severe handicap in any electronic machine has been its dependence on vacuum tubes. In a large computer, where there are a great many tubes, breakdowns are occurring constantly. It was recently reported, for example, that in one computer employing several thousand tubes, there were six tube failures every day.

In the world of science, this defection is not too serious. If a computer were down for repairs 90 per cent of the time, it can still be eminently worthwhile for the job. For in that short 10 per cent of operating time, it might well perform work that would require a number of specialists many months to accomplish. Where the ultimate savings are many months and many men, it makes relatively little difference whether a job takes one week or two weeks.

"Time is of the Essence"

This does not hold true in the business world. Here, it is less a question of one or two all-important problems, but rather a flow of comparatively minor ones in the solution of which the time element is of vital concern. There has to be a premium on regularity and reliability.

At the research and experimentation level, efforts have been unsparing to improve the maintenance phase of electronic operation. Perhaps by replacing temperamental tubes with such items as transistors, or by employing new magnetic principles, we can hope for a remedy. It should be remembered, however, that a number of technical difficulties still lie in the path of these projects, that a great deal of work remains to be done.

It is well known, I think, that the initial price of computers is at present extremely high. That, of course, is relevant only when it is considered with the cost of doing the same work by other means. In the great bulk of office operation, the basic need is not an increase in the speed of the computation, desirable as this would be. The big cost item is still the time and labor required to handle the information on which computations are based. As long as that cost remains the same, we gain little by an investment that speeds up the arithmetic process. When the volume of computation becomes too great to be accomplished efficiently by other methods, then the expense of an electronic computer may be justified. In the great majority of business concerns, this consideration does not now apply. At the moment, the clerical work can be more economically handled in other ways.

Future Holds Problems

The question is not just one of solving the technological problems. This we can do. It is a question of finding solutions that will be economical for the user—and that is a very different matter. It awaits, I submit, a continuation of the same rate of progress that has provided, in so short a time, so many truly remarkable contributions in the field of science.

The assertion is often made that we are living in a new era—the Electronic Age. If we add the reservation that we are still at the very beginning of it, I believe that the assertion is true. We must face the fact that years of research, and development, and hard work are needed before today's vision can become, in truth, a workable reality.

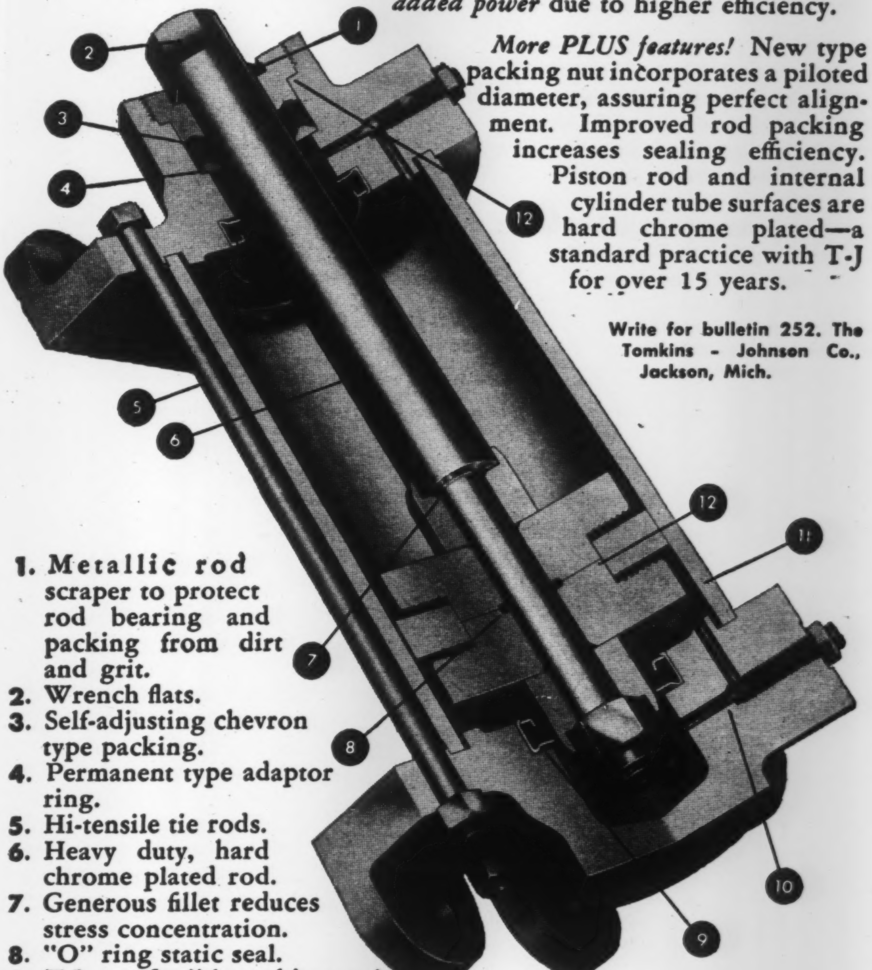
From an address of the same title given before the First National Convention of the National Machine Accountants Association in Minneapolis, Minn., June 1952.

New Flexible Sealing...
T-J AIR CYLINDER
Designed with revolutionary application of
Super-Cushion

It's *sealed with pressure*—a revolutionary T-J application of flexible sealing that insures positive cushion action combined with automatic valving action for fast return stroke ... eliminates binding and sticking ... operates with *low friction, minimum wear,* and *added power* due to higher efficiency.

More PLUS features! New type packing nut incorporates a piloted diameter, assuring perfect alignment. Improved rod packing increases sealing efficiency. Piston rod and internal cylinder tube surfaces are hard chrome plated—a standard practice with T-J for over 15 years.

Write for bulletin 252. The Tomkins - Johnson Co., Jackson, Mich.

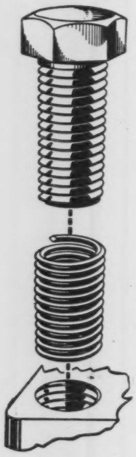


1. Metallic rod scraper to protect rod bearing and packing from dirt and grit.
2. Wrench flats.
3. Self-adjusting chevron type packing.
4. Permanent type adaptor ring.
5. Hi-tensile tie rods.
6. Heavy duty, hard chrome plated rod.
7. Generous fillet reduces stress concentration.
8. "O" ring static seal.
9. T-J new flexible cushion seal insures positive cushion with automatic valve action for fast return stroke. (Patent applied for)
10. Fine cushion adjustment.
11. Heavy wall precision honed hard chrome plate.
12. Controlled packing compression with metal to metal contact.

36 YEARS' EXPERIENCE T-J
TOMKINS-JOHNSON
RIVITORS AIR AND HYDRAULIC CYLINDERS CUTTERS CLINCHORS

a new twist
in thread
engineering

Heli-Coil* **Inserts present a new twist to screw threads. They armor your tapped holes with precision-formed stainless steel wire, and put an end to stripping and corrosion.**



This alone will be a decided advantage for your products in the competitive market. But there are still further basic design improvements and savings possible with *Heli-Coil* Inserts.

Smaller... fewer... or shorter cap screws can now provide the necessary holding power with *Heli-Coil* Inserts... even with short thread engagements. Cap screws can be repeatedly removed and replaced without damage to the threaded member when tapped threads are protected by *Heli-Coil* Inserts.

Make your designs cleaner, with lighter bosses and smaller flanges — by the use of *Heli-Coil* Inserts. Eliminate heavy studs and bolt-and-nut assemblies by using cap screws and *Heli-Coil* Inserts. In addition, your product is permanently protected against thread corrosion and seizure.

The value of *Heli-Coil* thread engineering to you is quickly verified. Take a minute now to get the latest information. It costs you nothing...mail coupon today!

*Reg. U. S. Pat. Off.

Conforms to all industrial and military specifications.

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COMPANY________________________________

ADDRESS________________________________

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Meetings

AND EXPOSITIONS

Oct. 16-17—

Gray Iron Founders' Society. Annual meeting to be held at Hotel Cleveland, Cleveland, Ohio. Additional information may be obtained from society headquarters, National City Bank Bldg., Cleveland 14, Ohio.

Oct. 16-18—

Foundry Equipment Manufacturers Association. Annual meeting to be held at the Greenbrier Hotel, White Sulphur Springs, W. Va. Additional information may be obtained from society headquarters, 1213 West 3rd St., Cleveland 13, Ohio.

Oct. 20-24—

American Society for Metals. National metal exposition and congress to be held at the Philadelphia Convention Hall, Philadelphia, Pa. W. H. Eisenman, 7301 Euclid Ave., Cleveland 3, Ohio, is national secretary.

Oct. 22-24—

Porcelain Enamel Institute. Twenty-first annual meeting to be held at the Greenbrier Hotel, White Sulphur Springs, W. Va. Additional information may be obtained from society headquarters, 1010 Vermont Ave., Washington 5, D. C.

Oct. 22-24—

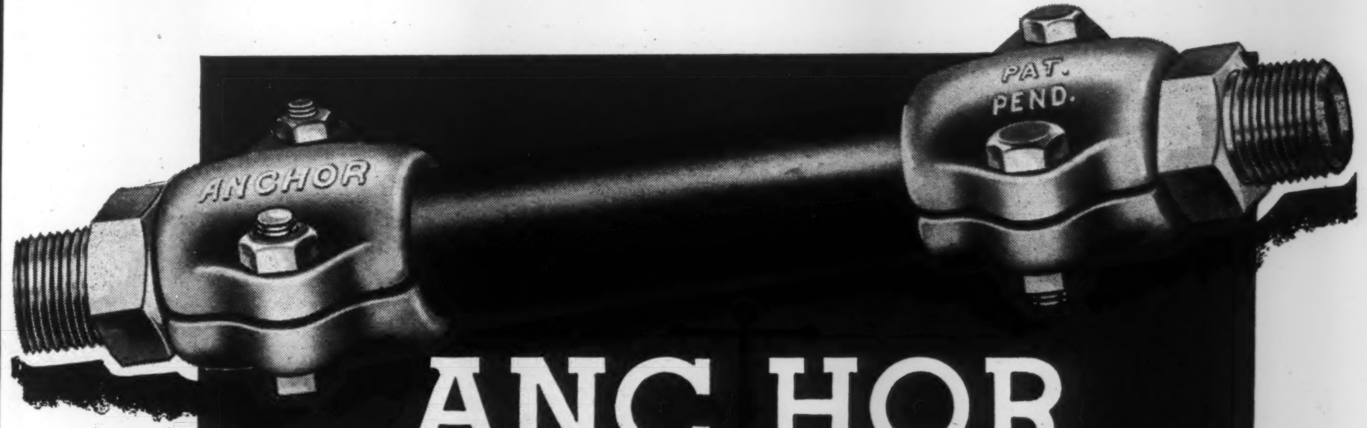
Society of Automotive Engineers. Transportation meeting to be held at the William Penn Hotel, Pittsburgh, Pa. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary.

Oct. 26-28—

American Gear Manufacturers Association. Semiannual meeting to be held at the Edgewater Beach Hotel, Chicago, Ill. J. C. Sears, 302 Empire Bldg., Pittsburgh 22, Pa., is executive secretary.

Oct. 29-31—

American Institute of Electrical Engineers. Fifth annual machine



ANCHOR

Clamp-Type, Reusable Coupling

Positive Grip—Easily Applied

...for hydraulic hose, ideal for both emergency field-repair service and original equipment application

Yes, here's a hydraulic hose coupling you can count on. It has a powerful grip and can be used with one- or two-wire braid hose for medium or high pressures, or fabric hose. Impulses can't shake it loose — yet it's reusable again and again, is put on or taken off quickly.

Because Anchor clamp-type couplings stay on the job, outlast the hose, hydraulic systems stay dependable, perform the way they were designed to perform.

Dependability isn't the only feature of this Anchor coupling ... just look at these advantages:

☆ **Neat installation** — made possible by compact design of the Anchor clamp and the use of streamlined Anchor adapter unions and related fittings.

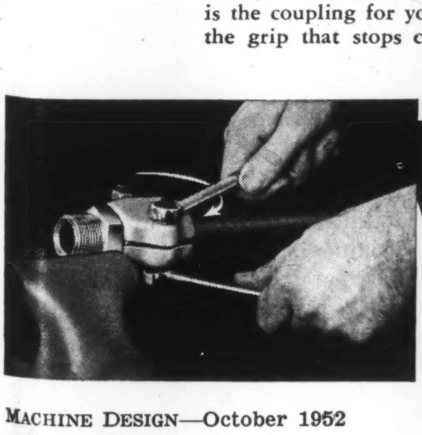
☆ **Easy to apply** — no special tools needed to attach or detach — just two automotive-type wrenches. And, it's unnecessary to strip the cover off the hose.

☆ **Built to take it** — clamping segments are specially designed to give the extra strength needed in hydraulic service, insert stem machined from high-grade steel rod stock, bolts are heat-treated and all parts are rust proof.

☆ **Saves time** — you don't have to wait for repairs because you can make up your hose lengths as needed. Stocking problem minimized.

This clamp-type coupling is widely used on equipment subjected to rough going. For example, many earthmoving and oil-field equipment manufacturers standardize on Anchor to assure maximum dependability under the toughest possible conditions. This is the coupling for you, too — the coupling with the grip that stops complaints. Write today for catalog of sheets giving size tables and recommended working pressures.

ANCHOR COUPLING CO., INC.
Factory: LIBERTYVILLE, ILLINOIS
Branch: DETROIT, MICHIGAN



Assembly is quick and easy, the grip firm and strong. No special tools needed.

Attach this Coupon to your Letterhead and Mail Today!

ANCHOR COUPLING CO., INC.
Dept. MD-102, Libertyville, Illinois

I want to know more about your clamp-type coupling that is so dependable and easy to use. Please send me catalog sheets.

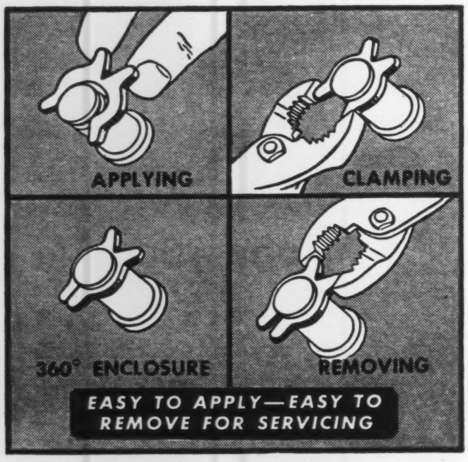
Name...Position.................
Company...
Company Address...
City...(..........) State...............

D-8

"SURE, THE COMPANY I WORK FOR USES Standard X-WASHERS Don't They All?"

● No, not yet, Mac. But they're getting there. More and more manufacturers are finding STANDARD X-WASHERS the answer in so many applications. It's the modern locking device for pins and small shafts. No more fooling around with castellated nuts, cotter pins, and lockwire. No more scratches and cuts from sharp edges.

The diagram below shows you how quickly and easily STANDARD X-WASHERS clinch to a positive 360° closure. What's more, they can be removed just as easily when servicing is necessary. Reduce production time and costly failures with the safe and sure STANDARD X-WASHER.



Grooved pins available for all sizes of STANDARD X-WASHERS . . . parallel or headed type pins made to specifications. Send print for prompt quotation.

STANDARD Locknut and Lockwasher, Inc.
510 N CAPITOL AVE • INDIANAPOLIS 4 IND

tool conference to be held at the Hotel Ten Eyck, Albany, N. Y. J. M. Delfs, A.I.E.E. Machine Tool Sub-Committee, c/o General Electric Co., Schenectady 5, N. Y., is chairman.

Oct. 29-31—

American Society of Body Engineers. Seventh annual technical convention to be held at the Rackham Memorial Bldg., Detroit, Mich. Additional information may be obtained from society headquarters, 100 Farnsworth Ave., Detroit 2, Mich.

Oct. 30-31—

Society of Automotive Engineers. Diesel engine meeting to be held at Hotel Chase, St. Louis, Mo. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary.

Oct. 30-31—

Metals Casting Conference. Fifth annual meeting to be held at Purdue University, West Lafayette, Ind. Additional information may be obtained from C. T. Marek, Department of General Engineering, Purdue University, Lafayette, Ind.

Oct. 30-31—

ASME Fuels and AIME Coal Division Joint Conference to be held at the Bellevue-Stratford Hotel, Philadelphia, Pa. Additional information may be obtained from C. E. Davies, 29 West 39th St., New York, N. Y.

Nov. 6-7—

Society of Automotive Engineers. Fuels and lubricants meeting to be held at the Mayo Hotel, Tulsa, Okla. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary.

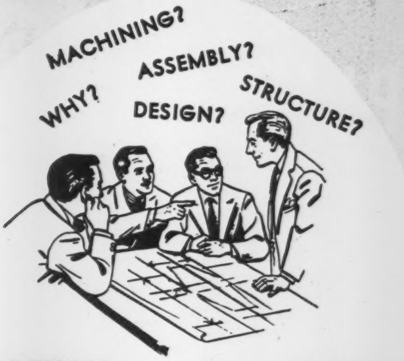
Nov. 29-Dec. 4—

American Society of Mechanical Engineers. Annual meeting to be held at the Statler Hotel, New York, N. Y. C. E. Davies, 29 West 39th St., New York, N. Y., is secretary.

Case
History
M-115

Here's what we mean by SUPERIOR ENGINEERED FOUNDRY PRODUCTS...

. . . another example of how proper product development at the drawing board pays off


MACHINING?
ASSEMBLY?
WHY?
DESIGN?
STRUCTURE?

PROBLEM:

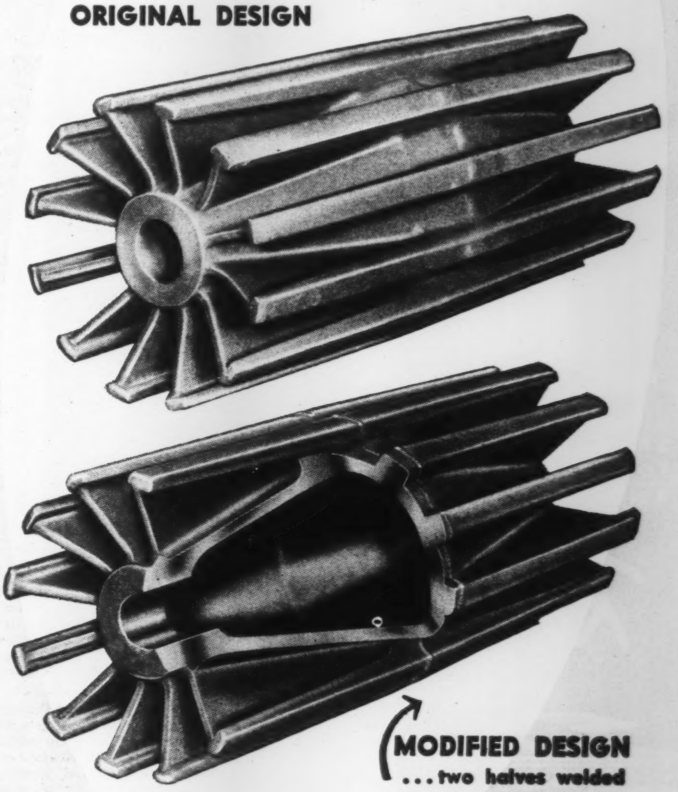
1. This 380-pound cast steel conveyor belt pulley was originally designed as a one-piece casting, making it difficult and expensive to produce.
2. The one-piece casting could not be gated and risered in a manner to insure delivery of sound castings.
3. The costly large center core could not be properly anchored to insure dimensional stability. Also, occasional cracking of the casting would occur during production.

SOLUTION:

FOUNDRY ENGINEERED CAST-WELD DESIGN. Cast the pulley in two halves designed to be compatible with good foundry practice. Weld the two halves together into a single unit.

RESULT: 13.6% SAVINGS

1. The improved foundry procedure, made possible by casting the pulley in two halves, required less expensive pattern equipment and reduced costs all down the line.
2. Efficient gating and risering insured consistently sound castings.
3. Elimination of the large center core greatly improved dimensional stability of the casting and eliminated the possibility of the casting cracking during production.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Review of Surface Finish Literature

By John W. Sawyer

Bureau of Ships
Department of the Navy

FOLLOWING is a continuation of the article "Review of Surface Finish Literature" which began in the September issue of Machine Design, Page 147. This month brief abstracts of articles published in 1945, 1946 and 1947 are presented; last month the years from 1948-1951 were covered. The November issue will contain a cross-reference subject index of the abstracts.

1947

1-47. "Control and Measurement of Surface Finishes"—J. A. Broadston; *Steel,* v. 120, n. 2, January 13, 1947, pp. 82-83, 116, 118, 121. See also *Iron Age,* v. 159, n. 12, March 20, 1947, pp. 51-55 and *American Machinist* v. 91, n. 8, April 10, 1947, pp. 102-103. Recommended principles and procedures regarding selection and utilization of existing instrumentation in controlling surface quality of products whose performance depends upon proper surface finish, and for future improvement of surface finish measurement instrumentation; emphasis on present need for universal reference standard for finishes to control surface quality of machined parts on production line. (EI)

2-47. "Structure des Surfaces Polies"—H. Raether; *Metaux et Corrosion,* v. 22, n. 257, January 1947, pp. 2-17. Structure of mechanically or electrolytically polished surfaces; review of different methods of surface examination. It is shown how, by means of electrons, fine structure of surfaces can be penetrated, and that combined use of electron diffraction and electron microscope is important contribution to study of surface structure. (EI)

3-47. "The Structure and Appearance of Metal Surfaces"—J. H. Nelson; *Metal Treatment,* v. 13, Winter 1946-1947, pp. 279-285. Effect of surface defects of various magnitudes on the surface appearance of metallic objects. Particular attention to the process of "superfinishing". (ASM)

4-47. "Evaluates Finishes"—*Steel,* v. 120, March 17, 1947, p. 112. Evaluation of surface finish or roughness is obtained by a new National Bureau of Standards method in which a carefully prepared plastic replica of the surface is analyzed by photoelectric means. Replica is produced by applying a suitable solvent to the test surface and pressing on a strip of clean plastic film. When dry, the film is readily stripped from the surface. (ASM)

5-47. "Practical Aspects of Surface Finish Measurement Instrumentation" — James A. Broadston; *Iron Age,* v. 159, March 20, 1947, pp. 51-56. Practical application of suface finish control. Development of finish control and instruments available for measuring surface finish in the plant. Effectiveness, costs and methods of using various types of finish control devices. (EI)

6-47. "Requirements in Surface Finish"—D. McConnell; *Journal and Proceedings of the Institute of Mechanical Engineers,* v. 153, 1945 (War Emergency Issue No. 10), pp. 341-342; Same, *Engineering,* v. 159, March 23, 1945, p. 238. (IAI)

7-47. "Superfinishing Methods and Applications, Part I"—E. L. Hemingway; *Machinery,* v. 53, March 1947, pp. 154-158, 174. Details of the superfinishing process and methods of applying it to flat and cylindrical parts. (ASM)

8-47. "Surface Roughness, Waviness, and Lay, Part I"—American Standards Association; American Standard B46.1-1947, 7 pages.

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Sponsors: Society of Automotive Engineers and American Society of Mechanical Engineers. Standard is concerned with geometrical irregularities of surfaces of solid materials; definite classifications established for various degree of roughness and waviness, and for several varieties of lay; set of symbols provided for use on drawings, and in specifications, reports, etc. (EI)

9-47. "Effect of Surface Finish on Fatigue Limit of Mild Steel"—J. S. Caswell; *Product Engineering*, v. 18, March 1947, p. 152. Investigations on the effect of surface scratches in the direction of and transverse to the principal stress direction. Fatigue tests were carried out on mild steel specimens ground and polished in a circumferential direction, and also on other specimens, which were ground and polished in a longitudinal direction. Probable stress distribution along a diameter for specimens ground and polished in the two ways. (ASM)

10-47. "Surface Roughness, Waviness and Lay, Part I"—*American Machinist*, v. 91, April 10, 1947, p. 155. Standard is concerned with the geometrical irregularities of surfaces of solid materials. Establishes definite classifications for various degrees of roughness and waviness, and for various varieties of lay. It deals only with their height, width, and direction. (ASM)

11-47. "Surface Finish Measurement Instrumentation"—James A. Broadston; *Instruments*, v. 20, April 1947, pp. 374-377. Advantages for production of metal parts and equipment. (ASM)

12-47. "Surface Quality Control Does Pay"—J. A. Broadston; *American Machinist*, v. 91, April 10, 1947, pp. 102-103. (IAI)

13-47. "Superfinishing Methods and Applications, Part II"—E. L. Hemingway; *Machinery*, v. 53, April 1947, pp. 168-171. Typical applications of the superfinishing process on bearings and shop tools, and for inspection work. (ASM)

14-47. "New Replica Techniques for Evaluating Engine Wear"—*Automotive and Aviation Industries*, v. 96, n. 8, April 15, 1947, pp. 36-37, 78. Two methods of evaluating surface finishes of engine parts subject to wear; National Bureau of Standards process developed by H. K. Herschman is based on use of plastic replica which reproduces in minute detail protuberances and recesses of surface, and photoelectric means of evaluation. Process developed by NACA Aircraft Engine Research Laboratory; also uses plastic replica, but examination is made by microscope. (EI)

15-47. "Optical Methods for Evaluation of Metal Surfaces"—A. A. Vernon and J. Broomfield; *Metal Finishing*, v. 45, n. 4 April 1947, pp. 70-71. Classification and principles of available instruments; discussion of those showing picture of surface and one which measures light reflected from surface; surface pictures for comparative evaluation; dual microscope for visual comparison; quick scanning surface comparator operating on reflection principle. Bibliography. (EI)

16-47. "Surface Analyzer for Estimation of Roughness"—M. M. Tennenbaum; *Factory Laboratory* (U.S.S.R.), v. 13, May 1947, pp. 635-637. (In Russian). Motion of a needle point over the surface of the specimen is amplified by two piezo-elements and recorded graphically by a moving pen. Curves produced by the instrument and true surface profiles are presented in pairs for several types of surfaces. Reason for differences is explained on the basis of the finite dimensions for the needle point. (ASM)

17-47. "Tracer-Point Sharpness as Affecting Roughness Measurements"—D. E. Williamson; *Transactions of the American Society of Mechanical Engineers*, v. 69, May 1947, pp. 319-323. Test procedure proposed to show the differences in average roughness readings that are obtained on a variety of specimens using tracer points of different sharpness. Four diamond points were obtained in mounts to suit them for use in the common type of profilometer tracer. Measurement of average roughness on metal surfaces finished with abrasives can be satisfactorily carried out by tracer-point methods. Regardless of the smoothness of the piece, a tip radius of 0.0005-inch is adequate. (ASM)

18-47. "David Brown and Sons Topograph Surface Recorder"—*Engineer*, v. 183, May 9, 1947. (IAI)

19-47. "Surface Finish Measurement Instru-

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mentation"—James A. Broadston; *Instruments*, v. 20, June 1947, pp. 570-572. Requirements and problems involved. (ASM)

20-47. "Smooth Surfaces Increase Plain-Bearing Capacity" — E. L. Hemingway; *American Machinist*, v. 91, n. 12, June 5, 1947, pp. 92-95. Results of tests to study effects of rough and wavy surfaces and dimensional or geometrical inaccuracy of bushings and shafts on load-carrying capacity and life of plain bearings. Tests with recording wattmeter show smooth surfaces will carry heavier loads, run cooler, can be fitted to closer tolerances, and suffer much less wear. (EI)

21-47. "Measuring Millionths with New British Surface Measuring Instrument; Topograph"—*Steel*, v. 120, June 2, 1947, p. 114. (IAI)

22-47 "New Replica Techniques for Evaluating Engine Wear; Surface Finishes Reproduced in Plastic"—*Automotive and Aviation Industry*, v. 96, April 15, 1947, pp. 36-37. Excerpt. *Product Engineering*, v. 18, June 1947, p. 146. (IAI)

23-47. "How to Measure Surface Roughness of Castings"—G. Hobman; *American Machinist*, v. 91, n. 14, July 3, 1947, pp. 94-95. Details of Hobman-Meehanite surface meter—direct reading, portable instrument of stylus type. Readings of ordinates are taken at 0.01-inch increments and recorded graphically. Included is list of required classifications covering all normal ranges of surface roughness presently encountered. (EI)

24-47. "Measures Contours of Surfaces"—F. R. Nitchie Jr.; MACHINE DESIGN, v. 19, July 1947, p. 136. Mechanical instrument developed to measure the dimensions of marine propellers to tolerances much smaller than those generally accepted. This instrument should prove useful for any application requiring the measurement of radial or concentric cylindrical contours or sections, particularly of irregular surfaces. (ASM)

25-47. "Unusual Applications of Superfinishing"—E. L. Hemingway; *Machinery* (London), v. 71, August 7, 1947, pp. 156-157. Superfinishing of reamers and punches to improve results and life; of steam-valve disks and seats to reduce steam leakage; of pump piston-rods to eliminate the rasp effect between the rod and the nonmetallic packing; of gun recoil pistons to improve performance of aircraft engine parts to stop scoring; and of diesel engine crankshafts and automobile tappet valves to improve smoothness where they contact mating parts. Inspection of metal surfaces. (ASM)

26-47. "Testing of Flatness by Bean Comparator Method"—R. Marrinar and W. O. Jennings; *Engineer*, v. 184, n. 4778, August 22, 1947, pp. 164-165. Method described was devised at National Physical Laboratory and used for testing quickly and with reasonable accuracy large batches of surface plates of same size; it is particularly convenient for testing flatness of surfaces during manufacture. Principle is that of comparing, by means of sensitive dial indicator, straightness of succession of generators in surface under test with that of known reference straightedge. (EI)

27-47. "Determining Surface Roughness"—W. Mikelson; *Mechanical Engineering*, v. 69, n. 5, May 1947, pp. 391-393; see also *Mechanical World*, v. 122, n. 3162, August 22, 1947, pp. 199-200; *Engineers' Digest* (British Edition), v. 8, n. 9, September 1947, pp. 293-294. Use of new standard surface roughness specimens, depicting 10 degrees of roughness with total of 25 different finishes; set consists of 10 metal blocks; each 2 x 2½ inch, each identified by letter and representing certain degrees of roughness; several are subdivided into two or four different surfaces to show finishes of same degree of roughness, but made by different types of machines. (EI)

28-47. "Analysis of Surface Quality of Zinc-Base Die Castings"—A. W. Sundwick; *Steel*, v. 121, September 15, 1947, pp. 94-95. Same abr. *American Machinist*, v. 91, September 25, 1947, pp. 127, 129, 131. (IAI)

29-47. "Mobile Laboratory Measures Surface Finish in Shop"—A. A. Goodman; *American Machinist*, v. 91, n. 22, October 23, 1947, pp. 104-105. Features of small analyzer installed at Steam Div., Westinghouse Electric Corp. Standard complement carried in mobile unit consists of type "Q" profilometer and type "V" Motorace for machine controlled operation of various profilometer tracing heads. (EI)

30-47. "Fine Finishes and Flatness Ob-

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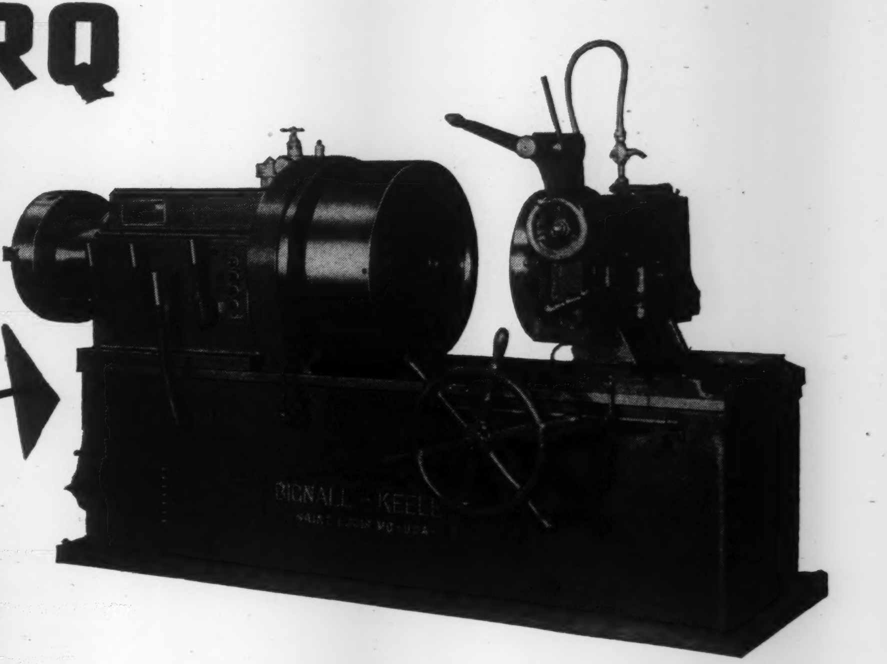

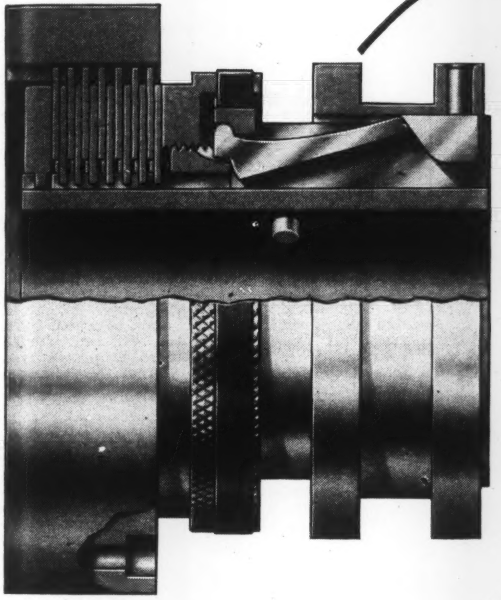

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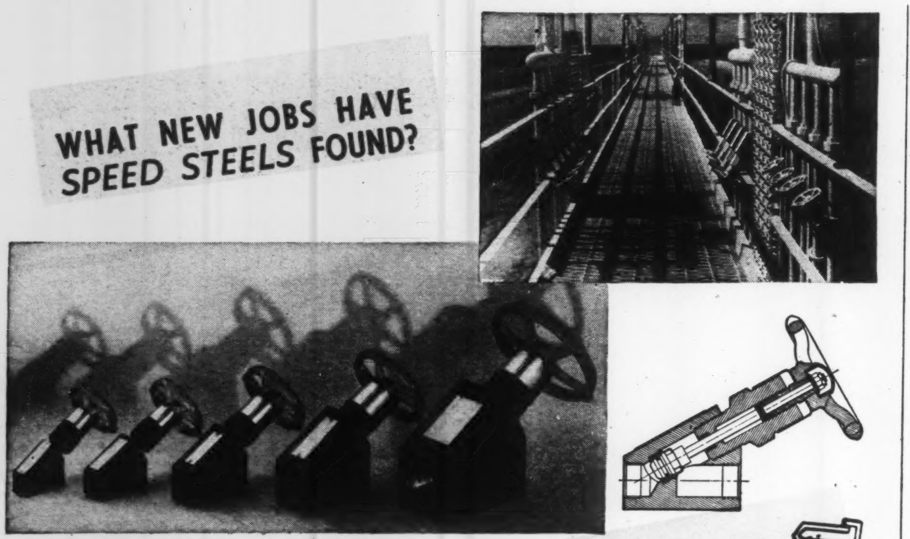

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tained by Surface Grinding"—*Machinery,* v. 54, October 1947, pp. 152-153. Production of finishes varying from 2 microinches for hardened steel to 15 microinches for aluminum. (ASM)

31-47. "Surface Hardness Comparator"—*Industrial Diamond Review,* v. 7, October 1947, p. 298. British-made comparator consists of a plastic holder with nine projecting steel pins of different hardnesses. To determine surface hardness, adjacent pins are rubbed across the surface to be tested until one pin scratches the surface, whereas the other slides. (ASM)

32-47. "Finishing with Diamond Tools"—Paul Grodzinski; *Machine and Tool Blue Book,* v. 43, October 1947, pp. 174, 176, 178, 180. Finishing parts to one microinch with diamond single-point tools. (ASM)

33-47. "Surface Roughness Measured by Resistance to Air Flow; Rugosimeter"—*Product Engineering,* v. 18, November 1947, pp. 100-101. (IAI)

34-47. "Modern Mechanical Surface Finishing"—Martin Manier; *Metal Finishing,* v. 45, November 1947, pp. 62-66. A review of equipment, procedures and materials. 17 references. (ASM)

35-47. "Dry Friction of Metals as Affected by Surface Finish and Surface Coatings"—N. Ludwig; *Engineers' Digest* (American Edition), v. 4, November 1947, pp. 516-517. Apparatus for measuring sliding frictional resistance by use of a test cube pressed against a plane surface. Effect of surface finish was determined for four metals or alloy and for four grades of mechanical smoothness—rough machined; fine machined; ground; and polished. The frictional resistance of ten different surface coatings of either phosphated or plated types was also determined. (Translated and condensed from *Die Technik,* v. 2, April 1947, pp. 166-170). (ASM)

36-47. "Surface Finish Measurement of Engineering Components"—C. Timms; *Journal of the Institution of Production Engineers,* v. 26, n. 12, December 1947, pp. 411-426. Measurement and analysis of surface irregularities of materials; results of research program of National Physics Laboratory in England; stylus types of instrument capable of recording to high scale of magnification surface irregularities which hitherto have been assessed by practical workshop methods such as fingernail test; other instruments. (EI)

1946

1-46. "Checking surface finish; Comparoscope"—*Steel,* v. 118, January 28, 1946, p. 115. (IAI)

2-46. "Surface Finish of Reduction Gear Teeth"—J. A. Davies; *Journal of the American Society of Navy Engineers,* v. 58, February 1946, pp. 16-20. Use of Faxfilms for inspection of gear tooth surfaces. Process can be and has been used on any surface the condition of which is subject to question. (ASM)

3-46. "Optical Methods for the Examination of Surfaces"—B. Firschmuth. *Industrial Diamond Review,* v. 6, March 1946, pp. 70-74. Optical methods used at present for the examination of surface finish, particularly the Schmaltz "light-slit" method. Adapter is described which enables method to be carried out with the aid of a standard inverted type metallurgical microscope. Usefulness of adapter is illustrated in a number of photomicrographs, obtained with various types of surfaces. (Translated from *Schweizer Archiv fuer angew, Wissenschaft and Technik,* v. 11, September 1946, pp. 262-269.) (ASM)

4-46. "Surface Finish; what surface profile is really like, as shown by ordinary and electron microscopes"—L. H. Milligan; *Diesel Power,* v. 24, March 1946, pp. 336-338. (IAI)

5-46. "Determination of Surface Roughness by Use of Longitudinal Feelers and by Interference Techniques"—F. Flamant and M. A. Arnulf; *Journees des Etats de Surface,* 1946, pp. 110-116; discussion, p. 116. Application of individual methods to different surfaces, after simple machining, grinding, mechanical or electrolytic polishing. (ASM)

6-46. "A Glossmeter for Smoothness Comparisons of Machine-Finished Surfaces"—Richard S. Hunter; *Journal of the Optical Society of America,* v. 36, March 1946, pp. 178-181. Since shininess is one indication of surface

NORGREN regulator-lubricator setup solves precision control problem on pipe cutter

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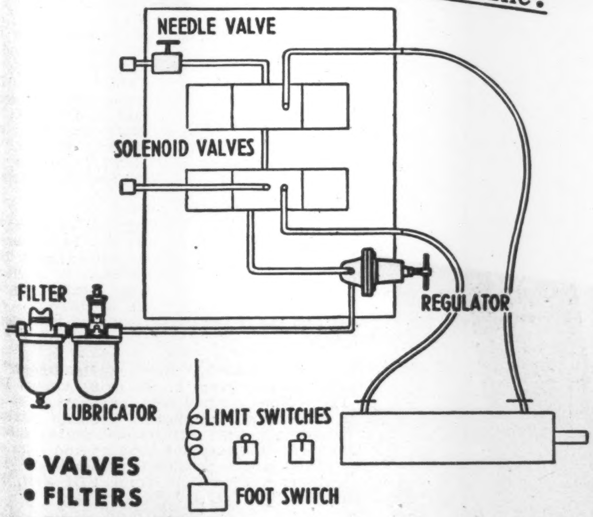

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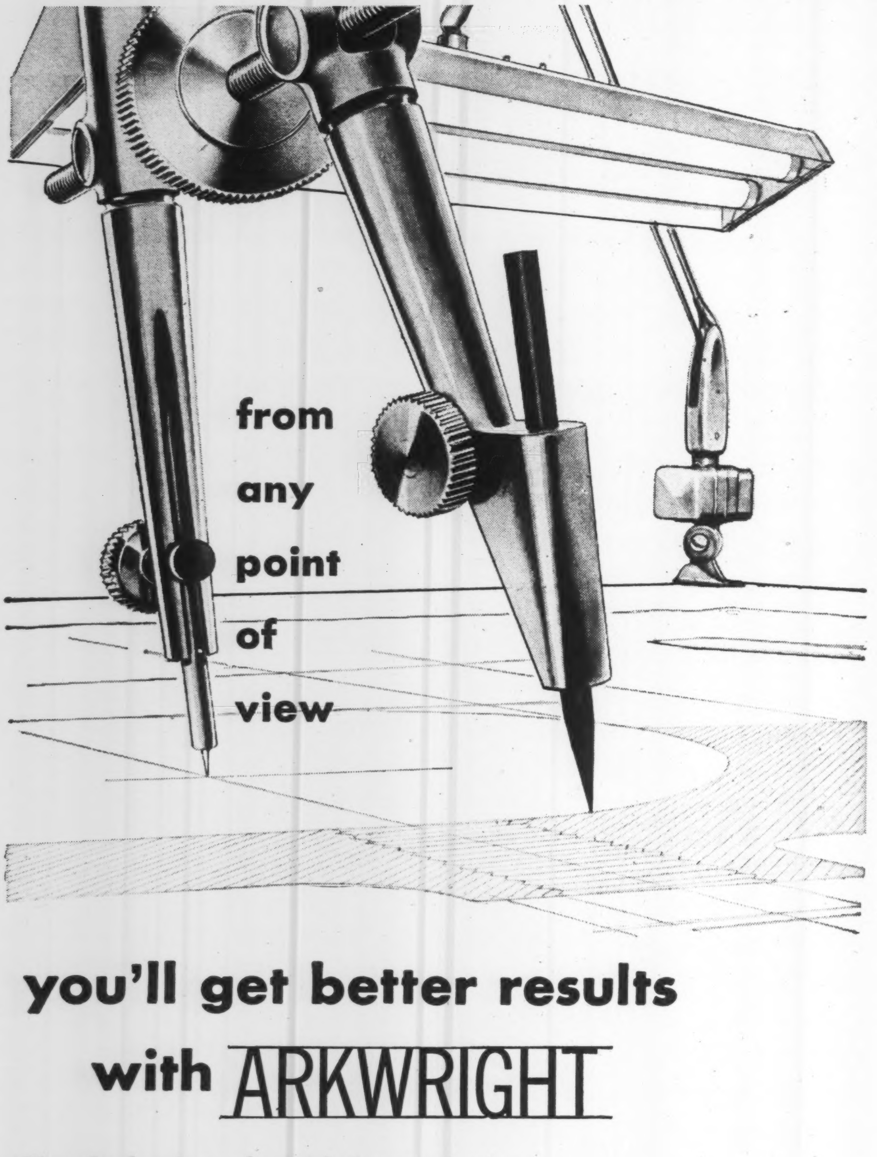

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smoothness, a photoelectric glossmeter was developed for possible use as a production-inspection device for determining the roughness of machine-finished surfaces between 100 and 500 microinches root mean square deviation from mean surface. (ASM)

7-46. "Putting a Glassy, Smooth Finish on the Shooting Star"—Fred M. Burt; *Industrial Finishing,* v. 22, March 1946, pp. 27-32. New materials and technique used to condition all metal surfaces. Gives 11 important steps in superfinishing schedule. (ASM)

8-46. "Conference on Surface Finish" — *Journal and Proceedings of the Institution of Mechanical Engineers,* v. 153 (War Emergency Issue No. 10), pp. 331-351. *Engineering,* v. 159, March 16-April 13, 1945, pp. 215-220, 237-239, 258-260, 277-280, 299; same, condensed in *Engineer,* v. 179, March 16-30, 1945, pp. 218-220, 230-231, 250-251. Discussion: *Journal and Proceedings of the Institution of Mechanical Engineers,* v. 153 (War Emergency Issue No. 10), pp. 352-379; *Engineer* v. 179, March 16-23, 1945, pp. 209-211, 234-236. (IAI)

9-46. "Polissage Electrolytique et Superfinition"—R. Mondon; *Technique Moderne,* v. 38, n. 23-24, December 1-15, 1946, pp. 281-286, v. 39, n. 1-2, January 1-15, 1947, pp. 17-21. Electrolytic polishing and superfinishing; various types of finishing; application of profilometer to surface testing influence of electrolytic polishing on mechanical properties; application to detection of surface defects. (ASM)

10-46. "Measurement of Surface Roughness"—C. J. Posey, *Mechanical Engineering,* v. 68, n. 4, April 1946, pp. 305-306, 338; see also *Mechanical World,* v. 119, n. 3102, June 14, 1946, pp. 672-674. Regarding types of equipment used to measure surface roughness, paper mentions differences in British and American practices and points out that neither takes into account all factors involved; difficulty of defining concept of identical or similar surface roughness; use of histogram method of analysis by means of which depth, slope and curvature distribution characterizes profile roughness completely. (EI)

11-46. "Comparison of Roughness of Super-Finished Plane Surfaces"—J. Kluge and G. Bauchmann; *Product Engineering,* v. 17, May 1946, pp. 401-402. Foreign abstract. Instrument employing photoelectric cell developed to give qualitative measurement of surface roughness. Test compared with those of Schmaltz surface tester.

12-46. "The Surface Condition and Reflectivity of Metals"—J. H. Nelson; *Journal of the Electrodepositors' Technical Society,* v. 21, 1946, pp. 113-120 (Reprint). Theories of surface reflectivity are outlined. Superfinishing technique and method for comparison of finish smoothness are described. Application of reflectivity as a tool in razor blade inspection is explained. (ASM)

13-46. "Measurement of Surface Roughness"—C. Timms, *Metal Treatment,* v. 13, n. 46 (Summer), 1946, pp. 111-118. Optical surface recording instruments developed for this purpose; range of roughness accommodated by each; difficulties to be overcome in order to establish rational specification for surface roughness and present progress; need for correlation between physical and geometrical aspects of surface to determine important surface qualities. Before Paris Congress, Organized by La Commission Technique des Etats et Proprietes de Surface des Metaux. (IAI)

14-46. "Les Etats de Surface"—Lasnier and Plagnol; *Journal des Societe des Ingenieurs de L'Automobile,* v. 18, n. 4, July-August 1945, pp. 117-130. Present knowledge of surfaces; definition; examination with mechanical and optical apparatus, electron microscope, electrical and other methods; study of behavior of surfaces. (EI)

15-46. "Measuring Surface Roughness" — *Product Engineering,* v. 17, n. 8, August 1946, p. 117. New method and apparatus for surface inspection; equipment consists basically of microscope with adjustable lighting shutter, translucent intermediate bender; and light concentrating lamp; application described. English abstract of article from *VDI Zeit,* February 20, 1945. (IAI)

16-46. "L'etat des surfaces metalliques"—P. Bastien and C. de Senneville; *Technique Moderne,* v. 38, n. 15, 16, 19, 20, August 1, 15, 1946, pp. 169-176; October 1, 15, pp. 223-228. State of metal surfaces. August: Physical and physical chemical state; methods of studying constitution and structure. October: Study of

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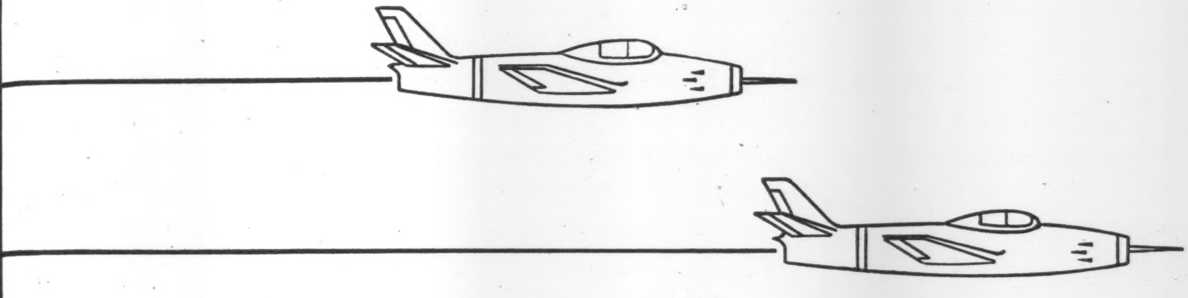

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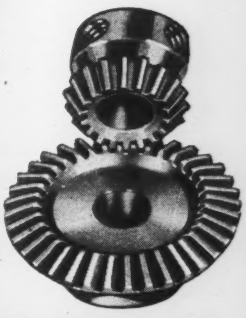

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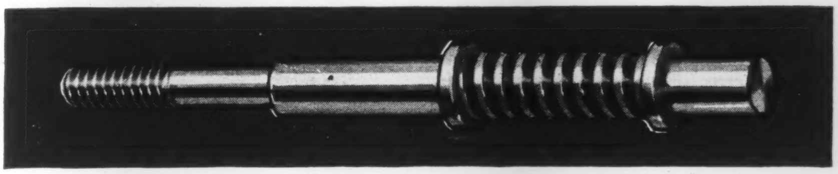

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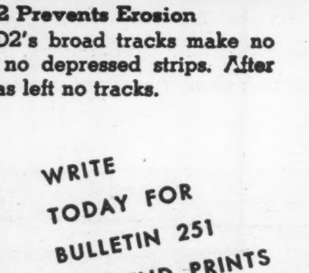

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Surface Finish

shape of surfaces; macro and micro roughne influence of surface state on friction, elect conductivity, hardness, fatigue and corrosi (IAI)

17-46. "Replica Method for Roughn Measurement"—H. Smoluchowski; *Review Scientific Instruments,* v. 17, August 1946, 309. Simple method which shows type roughness, and can be used in hard-to-get places. Cellulose acetate dissolved in aceto is applied. Before it dries, cellulose aceta tape is pressed on. When it is pulled off, bottom is covered with an accurate replica the surface. In a variation of technique, is added to the solution, so that the repl may be exposed to a light beam for quantit tive roughness determination with a photo-ce (ASM)

18-46. "Standard Classification of Machin Surface Finish"—P. E. Dyachenko; *Enginee Digest* (British Edition), v. 7, n. 9, Septe ber 1946, p. 297. Account of USSR standa classification of microsmothness of surfa based on root mean square value of deviati as measured on Abbott type surface measuri instrument; standard curve of equivalents g en to permit translating this in terms of ma imum deviation, should this other criterion necessary. Brief English abstract from *Ve nik Inzhenerov I Tekhnikov,* Russia, n. 1946, pp. 73-78. (EI)

19-46. "A New Approach in Evaluati Surface Roughness of Gear Teeth"—L. Martin; *Product Engineering,* v. 17, Septemb 1946, pp. 110-114. Standard for compari surface roughness of gear teeth by visual i spection.

20-46. "Suggestions Concerning Use of Co relation Charts for Interpretation of Surfac Finish Records"—J. R. Womersley and M. Hopkins; *Journees des Etats de Surface,* 194 pp. 135-139; discussion, p. 139. The profil gram obtained by an apparatus with feele does not define completely the condition of th surface. The true surface condition may determined only by meticulous analysis of series of profilograms compiled into a correla tion chart. (ASM)

21-46. "Precision Measurement, Section 1— Inspection Instruments, Continued; Part 3— Optical Flats"—Warren Baker. *Machine Too Blue Book,* v. 42, September 1946, pp. 141 142, 144, 146, 148, 150, 152, 154, 156, 158, 160 162, 164, 166, 168, 170, 172, 174. Theory and use of optical flats; examples. (ASM)

22-46. "Interference Microscope for Testing Surfaces"—*Industrial Diamond Review,* v. 6, n. 70, September 1946, pp. 276-279. Instrument for direct measurement of profile heights on smooth surfaces for maximum roughness of 0.05 to 2 micron (2 to 80 microinches) over certain portion of workpiece surface under test; method of testing, operation and adjustment; interpretation of interference patterns; design and mounting; use of photographic equipment and evaluation of pictures; calibration. (EI)

23-46. "Surface Finish in Production Methods"—W. E. R. Clay; *Institution of Mechanical Engineers Proceedings,* v. 153, 1945, War Emergency Issue No. 10, pp. 342-343. Grinding; honing; superfinishing; lapping. (Paper for Symposium on Surface Finish.) (ASM)

24-46. "Measurement of Surface Waviness" —C. Timms; *Institution of Mechanical Engineers Proceedings,* v. 153, 1945, (War Emergency Issue No. 10), pp. 337-339. A portable instrument of simple construction designed at the National Physical Laboratory for the measurement of the grosser surface irregularities. (Paper for Symposium on Surface Finish.) (ASM)

25-46. "How to Measure Surface Roughness of Castings"—G. Hobman; *American Foundryman,* v. 16, October 1946, pp. 46-47. Use of dial gage and stylus type contact point. (ASM)

26-46. "Surface Finish Measurement Instrumentation"—James A. Broadston; *Tool & Die Journal,* v. 12, October 1946, pp. 81-86, 106, 170. Various commercial instruments used. (ASM)

27-46. "Talysurf Surface Meter"—*Electronic Engineering,* v. 18, n. 225, November 1946, p. 351. Notes on stylus type of electronic instrument for measuring texture of surfaces; it provides both graph showing cross section of surface, and number representing average height of texture; suitable for measurement of all irregularities whose spacing lies in range

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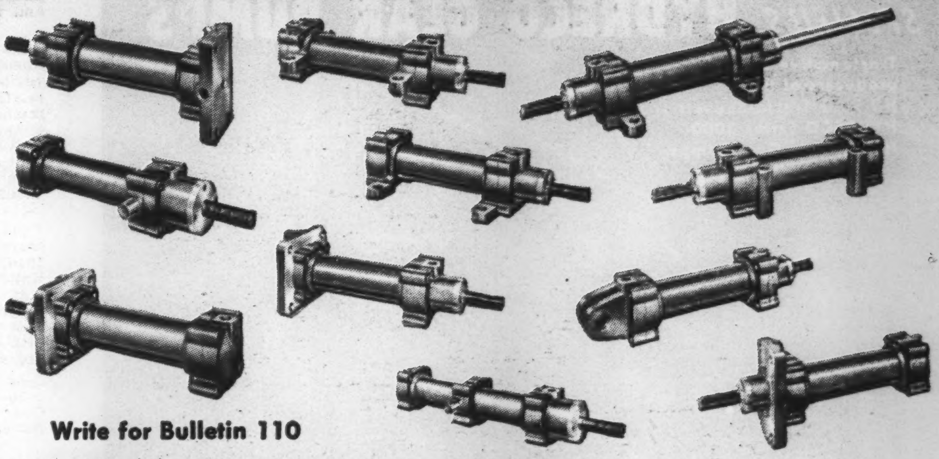

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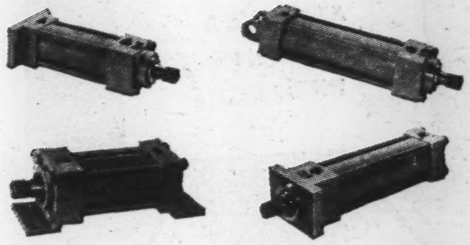

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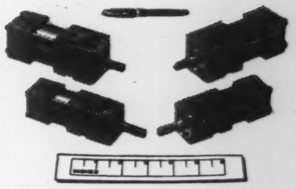

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Surface Finish

between about 0.0002-inch and 0.1-inch; applicability to grinding, fine turning and milling and fine finishing. (EI)

28-46. "Measurement of Surface Finish"—*Commonwealth Engineering,* v. 34, n. 4, November 1, 1946, pp. 130-134. Comparison o relative merits of taper sectioning, optica methods and stylus instruments for obtainin quantitative measurement applications. Article deals particularly with results obtaine and apparatus available for this purpose a Munition Supply Laboratories, Maribyrong Victoria. (EI)

29-46. "Profile and Surface Analysis"—*Aircraft Production,* v. 8, n. 97, 98, Novembe 1946, pp. 509-512; December 1946, pp. 557-560 November: Napier technique of checking gea teeth by combination of mechanical and optica magnification described. December: some variants of method as applied to surfaces of certain other components, including valve sleeves are dealt with. (EI)

30-46. "Evaluating Surface Roughness o Gear Teeth"—L. D. Martin, *Iron Age,* v. 158 November 21, 1946, p. 144. (IAI)

31-46. "Blow-Up Photos Facilitate Researc and Inspection"—M. W. Seavey; *Tool Engineer,* v. 17, November 1946, pp. 45-58. Photographing contour projections on optical comparator assists in the control of quality (ASM)

32-46. "Tapering for Surface Inspection"—W. J. Darmody; *American Machinist,* v. 90, n 26, December 19, 1946, pp. 134-135. Experiments with taper sectioning, conducted in connection with standardization of Ordnance finish blocks at Frankford Arsenal Gage Laboratory; taper sections formed by grinding and lapping of surface area to be evaluated; machining methods used to prepare block for surface inspection; lapping compounds used; utilization of two different ways of positioning light for examining surface finish under microscope. (EI)

33-46. "Comtor Surface Smoothness Comparator"—*Machinery,* v. 52, December 1945, p. 220. (IAI)

34-46. "Trentini Surface Tester"—*Industrial Diamond Review,* v. 6, December 1946, p. 375. Swiss instrument in which surface finish or roughness is measured by producing shocks in an electrical system. These shocks are produced by drawing a needle with a blunt point across the surface at constant velocity and under constant load, the magnitude of the impulses being proportional to the roughness of the measured surface. (ASM)

35-46. "Profile and Surface Analysis, Part II"—*Aircraft Production,* v. 8, December 1946, pp. 557-560. Combined mechanical and optical methods for checking by projection as applied to surfaces of certain components, including valve sleeves. (ASM)

1945

1-45. "Evaluation of the Finish of a Metal Surface by a Replica Method"—Harry K. Herschman; *National Bureau of Standards Journal of Research,* v. 34, January 1945, pp. 25-31. Method for evaluating surface finish through the medium of a nearly transparent plastic replica of a surface described. The method consists essentially in passing a narrow beam of light transversely through the moving replica onto a photoelectric cell. Variations in the geometric characteristics of the film, which are associated with the serrations of the surface reproduced, control the intensity of the light passing through the film and reaching the photocell at any instant. The fluctuations of intensity of the transmitted light cause a pulsating voltage in the cell circuit, which is recorded by an electronic voltmeter. This voltage increases with increased surface roughness. The evaluations obtained by this means are very promising. Results for different surface finishes are correlated with profile measurements of the surface determined with the microscope. (ASM)

2-45. "Surface Roughness Testing"—J. M. Trytten; *Metals and Alloys,* v. 21, January 1945, p. 138. (IAI)

3-45. "Lubrication; Newer Aspects Created by Superfinishing"—*Automobile Engineer,* v. 35, January 1945, pp. 21-23. (IAI)

4-45. "Determination of Surface Quality"—

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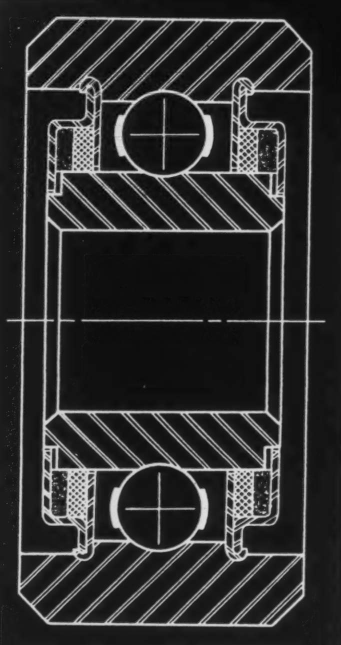

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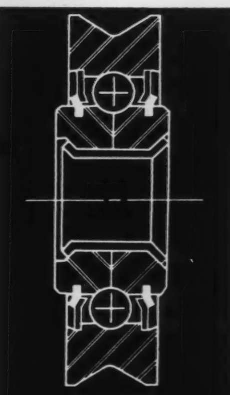

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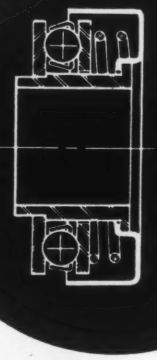

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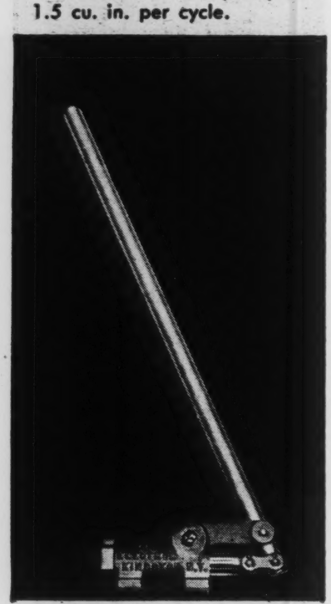

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Surface Finish

(Abstract)—*Metals and Alloys,* v. 21, Januar 1945, p. 234. (IAI)

5-45. "Surfaces Inspected by Three-Dimen sional Film; Faxfilm Method"—*Steel,* v. 11 February 19, 1945, p. 152. (IAI)

6-45. "Replica Method for Evaluating Fin ish of a Metal Surface"—Harry K. Hersch man; *Mechanical Engineering,* v. 67, Februar 1945, pp. 119-122. Describes a new method fo evaluating surface roughness which involve the use of rapidly produced plastic replicas o variable transparency. Evaluations of surfac finish made by this method on five specimen which differed significantly in degrees of finis were correlated with profile values of thes surfaces determined by (a) the profilomete method (as root-mean-square values), and (b the microscope on cross-sections (peak-to-valle values). These data show that this replic method is especially sensitive for the evaluatio of surfaces having high degrees of finish (ASM)

7-45. "General Electric Method of Designat ing and Inspecting Surface Fnish"—*Machinery* v. 51, February 1945, p. 184. (IAI)

8-45. "The Structure of Sliding Surfaces"— G. I. Finch; *Engineering,* v. 159, March 16 1945, p. 215. State of surface may be de termined by electron microscopy and diffrac tion. Root cause of breakdown in oil film i texture.

9-45. "Topograph for Measuring Surface Finish"—*Engineer,* v. 179, March 16, 1945, p. 215. (IAI)

10-45. "Some Principles and Methods of Surface Measurement"—R. E. Reason; *Journal and Proceedings of the Institution of Mechanical Engineers,* v. 53, 1945, (War Emergency Issue No. 10), pp. 335-337. Same, *Engineering,* v. 159, March 16, 1945, pp. 216-217. (IAI)

11-45. "Surface Finish Symposium"—*Engineer,* v. 179, March 16-30, 1945, pp. 218-220, 230-231; *Engineering,* v. 159, March 16-April 13, 1945, pp. 215-220, 237-239, 258-260, 277-280, 299; *Automobile Engineer,* v. 35, April 1945, pp. 141-146. Discussion, *Engineer,* v. 179, March 16-23 1945, pp. 209-211, 234-236. (IAI)

12-45. "Measurement of Surface Waviness" —C. Timms; *Engineering,* v. 159, March 16, 1945, pp. 217-220. Analysis of various surfaces and instruments. Pen charts.

13-45. "Drawing Office Specifications"—H. J. Griggs; *Engineering,* v. 169, March 23, 1945, p. 237. Standards proposed by British Standards Institution relating to symbols.

14-45. "Requirements in Surface Finish"— D. McConnell; *Engineering,* v. 159, March 23, 1945, p. 238. (IAI)

15-45. "Tomlinson Recorders" — *Engineer,* v. 179, March 23, 1945, pp. 237-238. (IAI)

16-45. "Results of Modern Practice"—F. Mourse; *Engineering,* v. 159, March 23, 1945, p. 239. Instruments replace visual inspection in aircraft work.

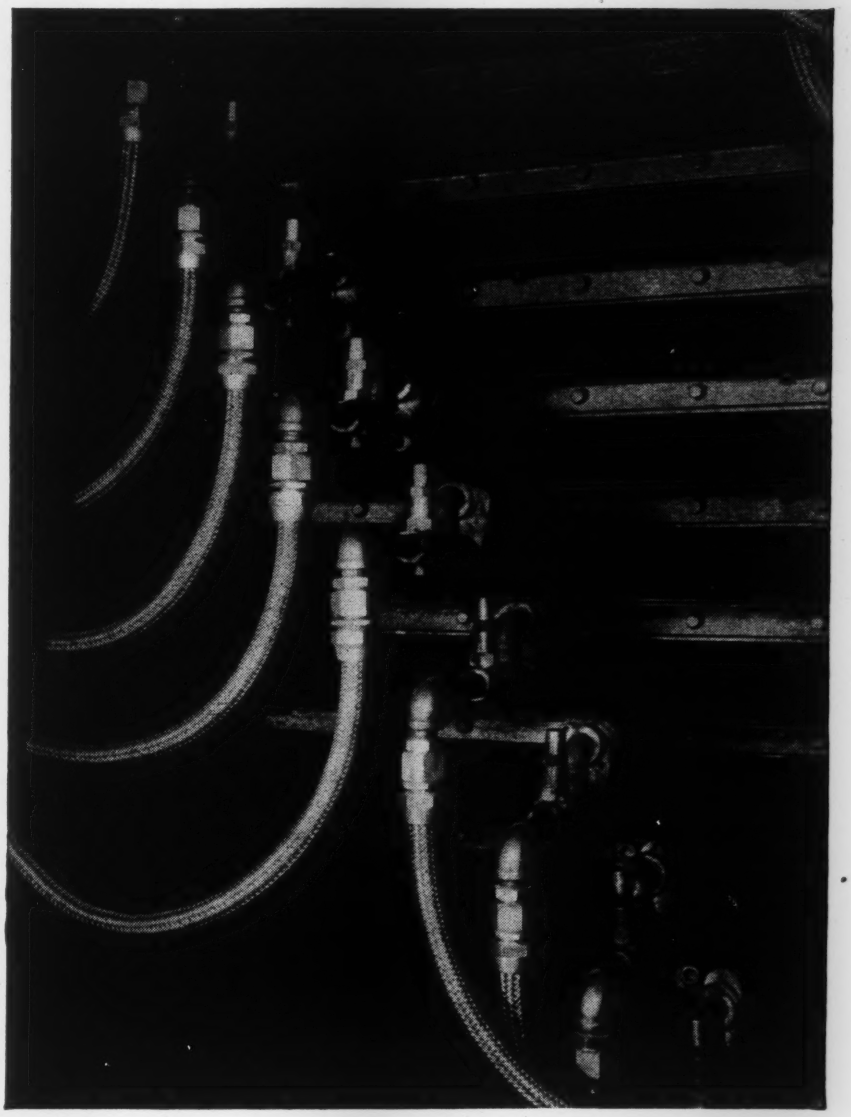
17-45. "Surface Finish"—*Engineering,* v. 159, March 16, 1945, pp. 211-212. General discussion of terms, machines, instruments and methods.

18-45. "Surface Finish on Production Methods"—W. E. R. Clay; *Engineering,* v. 159, March 23, 1945. Surfaces produced by grinding, honing, lapping and superfinishing. Degree of roughness and advantages of methods discussed.

19-45. "Symposium on Surface Finish: Continuity in the Production of Specified Surface Finish"—E. Swain; *Engineering,* v. 159, March 30, 1945, pp. 258-260. If a ground or honed finish is to be improved, the matter resolves itself into moderate finish with accuracy and speed of operation, as against fine finish, with slow operation coupled with the danger of generating excessive temperature, and its consequences. (ASM)

20-45. "Requirements in Surface Finish"— D. McConnell; *Journal and Proceedings of the Institution of Mechanical Engineers,* v. 153, 1945 (War Emergency Issue No. 10), pp. 341-342. Requirements of surface finish are concerned with the reduction of wear, and final decisions must largely rest on the observed results of work with known surface finishes. Paper for Symposium on Surface Finish. (ASM)

News about flexible metal connectors



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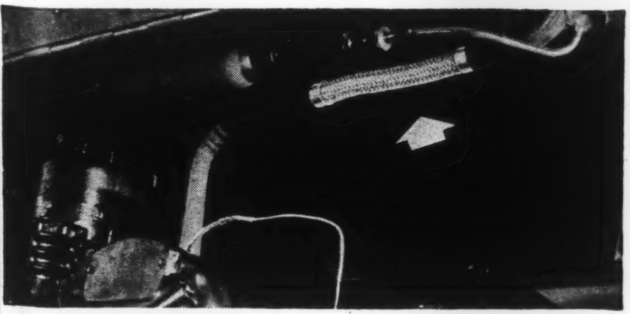
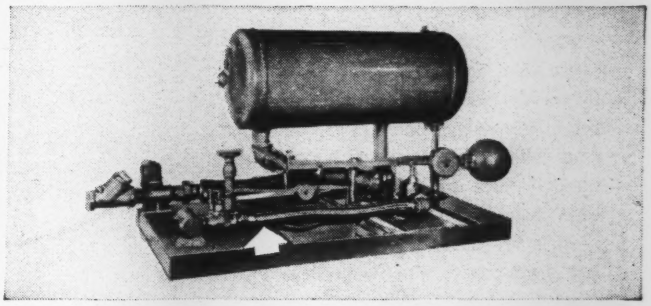


COLD For conveying Freon in truck refrigeration systems, The Schnabel Co. uses American Vibration Eliminators. These connectors operate between 10° and 40° F. at 180-200 p.s.i. American Flexible Metal Connectors are the best answer where moving lines must be connected, flexible shafts protected, or assemblies made in restricted spaces.



HEAT Morehead Manufacturing Company uses American Seamless Bronze Flexible Connectors on their "back to boiler" steam trap. This connector has the ability to resist high steam temperature and pressure as well. American Flexible Metal Connectors may also be used to carry corrosive liquids, gases, or semisolids.

52262

WRITE FOR BOOKLET SS-50—*shows how the tubing is designed, used, and installed—gives specifications on tubing and fittings. The American Brass Company, American Metal Hose Branch, Waterbury 20, Conn. In Canada: The Canadian Fairbanks-Morse Company, Limited.*

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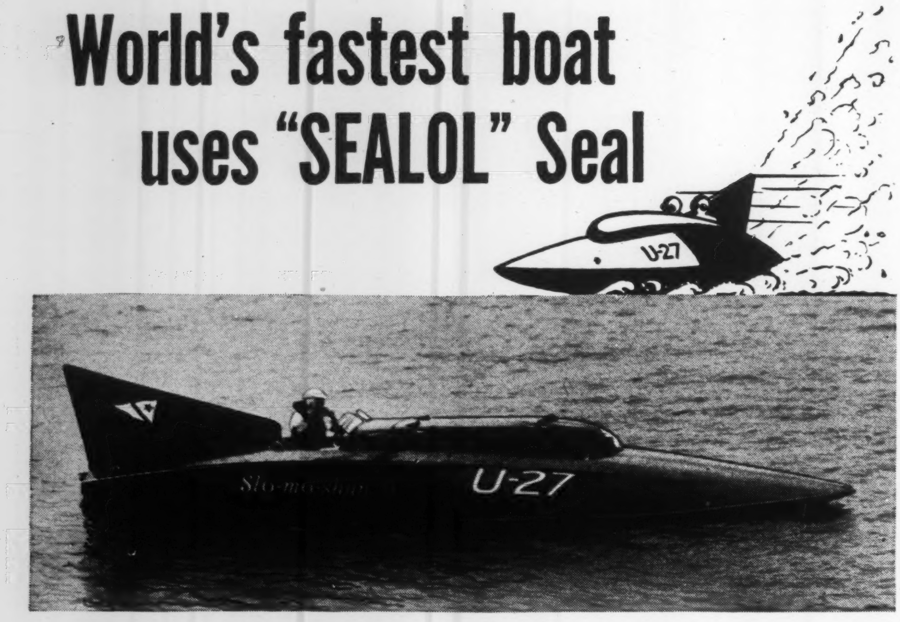

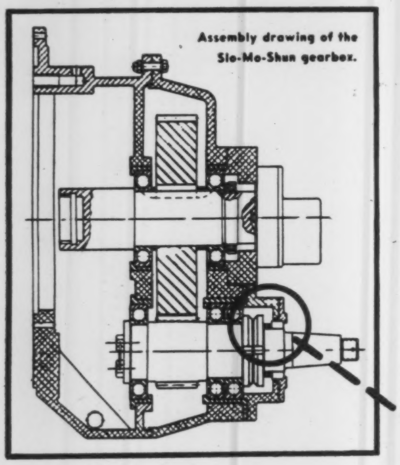

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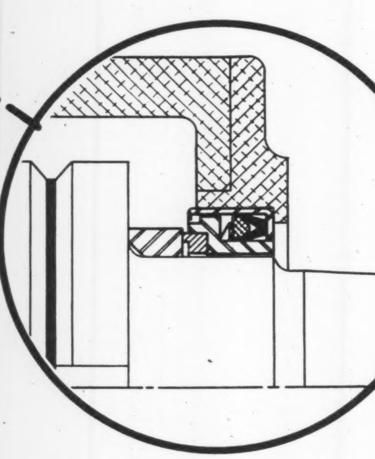

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SEALOL
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Surface Finish

21-45. 1944 Report on Measurement of S
face Finish by Stylus Methods—R. E. Reas
M. R. Hopkins and R. I. Garrod; Published
Taylor, Taylor and Hobson, Ltd., Leicest
England, March 24, 1944, 78 pages; char
tables, illustrations. See also review in *Au
mobile Engineer,* v. 35, n. 460, March 19
p. 119. Report on work done in past
years in Taylor-Hobson Research Laborato
basic elements of stylus instrument and limi
tions they may impose; various ways in wh
numerical assessment could be secured. Sty
instruments are built to give graph represe
ing cross-section of surface, or numerical
dication on meter, or both. (EI)

22-45. "Comparison of Surface Roughn
of Highly Finished Plan Surfaces"—J. Kl
and G. Bochmann. *VDI Zeitschrift,* v.
April 1, 1945, pp. 179-181. *Engineers' Dig*
(American Edition), v. 2, May 1945, pp. 2
216. Theory is advanced that it is less
portant to determine surface profile than
ascertain whether repeated refinishing of
surface will produce identical surface roughne
New apparatus developed for this. Instrum
operates on the principle of throwing a para
beam of light upon the surface under an an
of 45 degrees. Reflected beam is then pas
through a lens followed by an aperture and
photocell. (ASM)

23-45. "Talysurf"—*Engineer,* v. 179, Ap
6, 1945, pp. 276-277. (IAI)

24-45. "Effect on Fatigue Strength"—
Ker Wilson; *Engineering,* v. 159, April 6, 19
pp. 277-280. Sources of surface weakness
clude faulty geometrical shape, fretting cor
sion and wear, scaling, poor surface fini
mechanical damage and metallurgical defec
Influence of cutting, grinding and polishing
fatigue strength discussed. Strength and we
resistance can be increased by heat treatme
mechanical or surface coatings. Genera
finely finished surfaces are more desired.

25-45. "Some Principles and Methods
Surface Measurement"—R. E. Reason; *En
neer,* v. 159, March 16, 1945, pp. 216-2
Standardization of measuring instruments a
method discussed.

26-45. "Symposium on Surface Finish"
Machinery (London), v. 66, April 19, 19
pp. 427-429. Rational specification of surfa
finish; requirements in surface finish. (AS

27-45. "Symposium on Surface Finish"
Machinery (London) v. 66, April 26, 1945, p
457-458. Continuity in the production of spe
fied surface finish. (ASM)

28-45. "Surface Finish"—W. Ker Wilso
Aircraft Production, v. 7, n. 78, April 194
pp. 189-193. Effects of various workshop ope
ations on fatigue strength of steels are co
sidered; surface finish of aircraft engine com
ponents are dealt with. Many useful test r
sults are included and references made to u
of shot blasting for increasing fatigue strengt
Before Institution of Mechanical Engineer
(EI)

29-45. "Relation of Surface-Roughne
Readings to Actual Surface Profile"—L.
Tarasov; *Transactions of the American So
ciety of Mechanical Engineers,* v. 67, Apr
1945, pp. 189-196. Studies of surface finis
have shown the desirability of relating profi
ometer roughness readings to actual peak-to
valley distances of the type that a micromete
measures. Approximate multiplying factor
for converting profilometer readings into peak
to-valley roughness have been obtained from
taper sections of a variety of abrasive-finishe
steel surfaces with profilometer roughness i
the range of 1 to 100 microinches rms. Fo
cylindrical ground surfaces, the factor can b
taken as about 4½; for other types of fixed
abrasive finishes, as 6 or 7; and for loose
abrasive lapped surfaces, as 10. These a
mean values, and individual factors may devi
ate by as much as one-third of the main value
The factors quoted give values for "predom
inant peak" roughness; they should be doubled
to obtain "deepest maximum" roughness, thi
being a second way of describing the peak-to
valley roughness. (ASM)

30-45. "Surface Finish and Its Measure
ment"—R. E. Reason; *Journal of the Institu
tion of Production Engineers,* v. 23, n. 10
October 1944, Edition B, pp. 347-372. *Britis
Non-Ferrous Metals Research Association Bul
letin,* v. 25, April 1945, p. 95. Importance o
physical and geometrical aspects with emphasi
on the latter; basic stylus instrument; unit o
measurement; graphs of surfaces; use of spe

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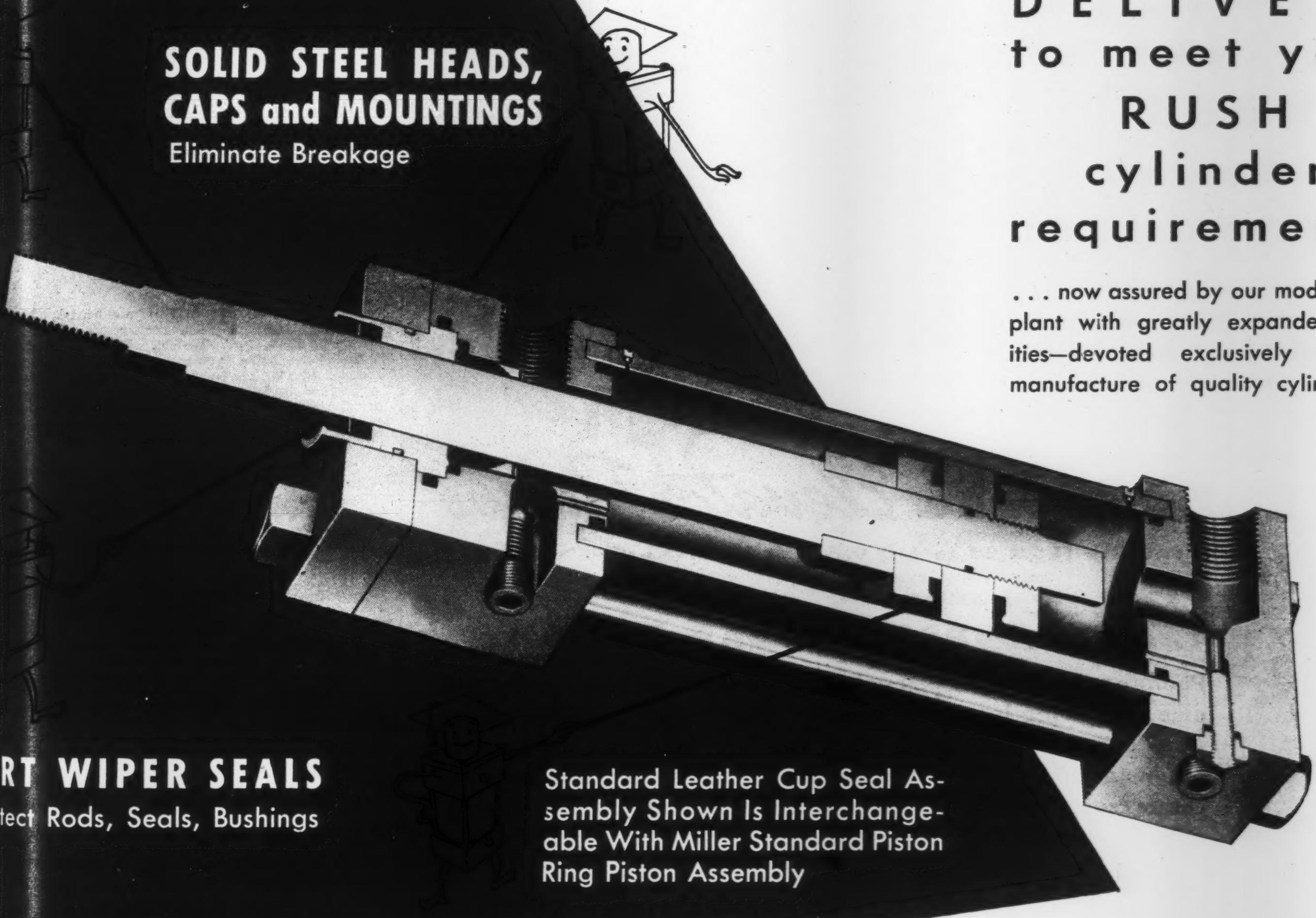

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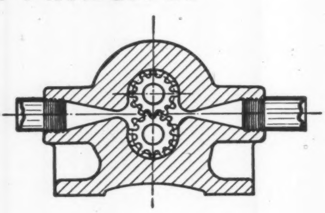

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Surface Finish

cial instruments (auto-collimator, waviness strument, roughness instrument with sk Tomlinson instrument, profilometer, Talysur in connection with measurement of differe kinds of surface imperfection. (ASM)

31-45. "The Measurement of Surface Fi ish"—H. P. Jost; *Liverpool Engineering Soci Transactions,* v. 65, 1944, pp. 49-70; *Iron a Steel Institute Bulletin,* n. 112, April 1945, p 154-A-155-A. (ASM)

32-45. "Locomotive Practices"—F. C. J hansen; *Engineering,* v. 159, April 13, 19 p. 299. Relation and importance of surfa finish to life of parts.

33-45. "Brown and Sons Surface Fini Measuring Instrument; Topograph"—*Autom bile Engineer,* v. 35, May 1945, pp. 203-2 (IAI)

34-45. "Surface Measurement" — *Aircra Production,* v. 7, n. 79, 81, May 1945, p. 21 July 1945, pp. 307-308. May: Topograph, troduced by David Brown and Sons Ltd. (Hu dersfield), operates on simple pneumatic pri ciple and gives pen-record of profile of surfa along selected straight track. July: For mea urement of fine surfaces, Pitter Gauge a Precision Tool Co. has developed portable o tical surface finish analyzer which incorpo ates in one unit a light source, an optical sy tem, and a reference lens. It is claimed th this method ensures absolute accuracy of su face measurement. (EI)

35-45. "Topograph Surface-Finish Measu ing Instrument"—*Engineering,* v. 159, n. 414 June 1, 1945, pp. 427-428. Illustrated descri tion of machine developed by David Brown a Sons Ltd. which operates on simple pneumat principle and gives pen record 10 inches lo by 5 inches wide, on paper, in 3 minutes, re ord being enlarged profile of surface irregula ties along selected straight line. (EI)

36-45. "Surface Roughness, Waviness a Lay"—*Engineering,* v. 159, n. 4144, June 1 1945, pp. 474-475. Editorial discussion of pr posed American Standard (B46) for surfa roughness, waviness and lay; revision of pr vious proposed standard distributed in Mar 1940. (EI)

37-45. "Evaluating Surface Finishes" *Steel,* v. 116, n. 26, June 25, 1945, p. 14 Accurate and rapid method of determini type and quality of surface finish of meta utilizes clear plastic film which "flows" ov surfaces. Replica then is stripped and surfa examined by passing it through narrow bea of light to register irregularities on photoele tric cell. (EI)

38-45. "Surface Replicas for Electron Mi croscopy"—L. Thomassen and others; *Revie of Scientific Instruments,* v. 16, June 194 pp. 155-156. (IAI)

39-45. "Surface Roughness"—L. P. Tara sov; *Industrial Diamond Review,* v. 5, Jul 1945, p. 162. Relationship of readings to a tual surface profile. (ASM)

40-45. "Optical Surface-Finish Meter"—*E gineering,* v. 160, n. 4148, July 13, 1945, p. 2 Meter for fine reflective surfaces manufacture by Pitter Gauge and Precision Tool Co. I strument, called PVE "Critic," is made in tw forms, one being for visual examinatio through microscope, and other arranged f both visual examination and for photograph record by means of camera attachment. (E

41-45. "Improved Profilometer" — *Aircra Production,* v. 7, n. 81, July 1945, p. 33 Details of new "Q" model of Abbots pr filometer for measurement of surface roug ness for large variety of parts. Reading representing average roughness of surfa measured in microinch units. (EI)

42-45. "Ultra-fine Surfaces on Metals" K. Rose; *Metals and Alloys,* v. 22, July 194 pp. 70-75. (IAI)

43-45. "Surface Comparison"—*Western M chinery and Steel World,* v. 36, July 194 p. 311. New process reproduces faithful specified machine finishes. It is a refineme on electroforming methods which permit pla ing with hard metals, and will reprodu exact facsimiles of surfaces down to th millionth of an inch. (ASM)

44-45. "Surface Measurement" — *Aircra Production,* v. 7, July 1945, pp. 307-308. O tical meter for fine reflective surfaces. (AS

45-45. "Interpreting Surface Roughne

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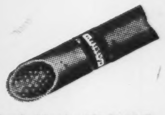

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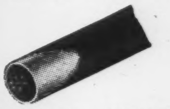

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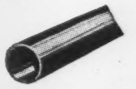

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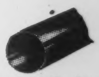

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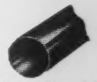

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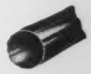

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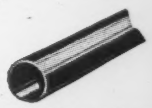

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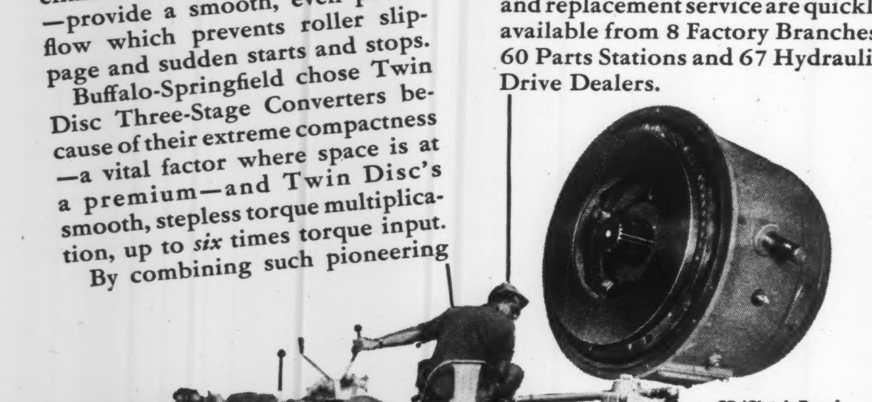

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Surface Finish

Readings"—L. P. Tarasov; MACHINE DESIGN, v. 17, August 1945, pp. 137-138. Shows how roughness measurements can be converted to linear microinches that can be visualized readily and handled in the same manner as any other linear dimension. (ASM)

46-45. "Rugosimeter; Instrument for Measuring Surface Roughness of Calendered Sheet Rubber"—M. Mooney, *Industrial and Engineering Chemistry, Analytical Edition,* v. 17, August 1945, pp. 514-517. Excerpts. *Rubber Age,* v. 57, September 1945, p. 724. (IAI)

47-45. "Optische Verfahren zur Pruefung der Oberflaechenguets" — B. Frischmuth; *Schweizer Archiv,* v. 11, n. 9, September 1945, pp. 262-269. Optical method for testing surface quality; illustrated description of various methods; details of auxiliary device with which, in combination with standard metal microscope, straightedge shadow method of O. Schmaltz can be employed. (EI)

48-45. "Surface Roughness; Proposed Standard Definitions and Symbols; Engineering File Facts"—*Metals and Alloys,* v. 22, September 1945, p. 775. (IAI)

49-45. "An Instrument for Recording Surface Waviness"—*Machinery* (London), v. 67, September 20, 1945, p. 327. Records waviness of a flat or curved surface, as instrument is moved over the face of the test piece. Contact with the surface is made by a small steel ball set in a sliding spindle. The latter is attached to a recording arm giving a continuous record. A suitable ratio of magnification is 50 to 1, and the record may be magnified again by about 50 when under optical examination. (ASM)

50-45. "Electron Microscopic Investigation of Surface Structure"—Robert D. Heidenreich; *SAE Journal,* v. 53, October 1945, pp. 588-594. Technique applicable to the study of the surfaces of rigid solids. Includes examples of structure of the bulk material as revealed by suitable etching techniques (metallography) and structure of the surface regions as they affect such factors as friction and wear, corrosion, adhesion of paints, and surface films. (ASM)

51-45. "A Bibliography on Methods for the Measurement and Specification of Surface Finish"—Department of Munitions, Munitions Supply Laboratories, Commonwealth of Australia, Maribyrong, Victoria, August 1945. One hundred articles, including outstanding papers, published between 1931 and 1945 have been abstracted.

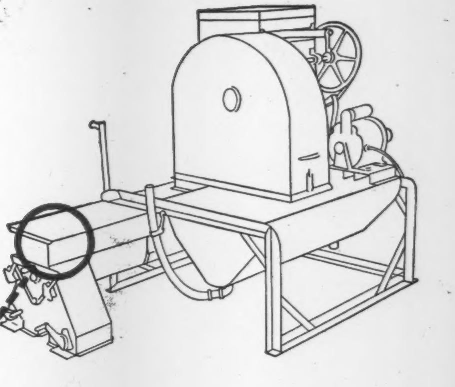
52-45. "Measurement of Finely Finished Surfaces by Optical Interference"—C. Timms; *Journal of Scientific Instruments,* v. 22, n. 12, December 1945, pp. 245-246. Method of measuring depth and pitch of fine surface irregularities as produced by lapping or similar refined processes by use of optical interference. It is strictly limited to fine finishes where surface irregularities do not exceed approximately 0.00001 in. in total depth. (EI)

53-45. "Les Etats de Surface"—L. Robida; *Technique des Industries Mecaniques,* 1945, pp. 51-55. Surface state of metals; definition; macro and microgeometrical deformations of surface; measurement by means of optical, electric or pneumatic methods; state of surface from physicochemical point of view; Chrysler superfinishing process. (EI)

54-45. "Rational Specification of Surface Finish"—W. A. Tuplin; *Journal and Proceedings of the Institution of Mechanical Engineers,* v. 153, 1945, (War Emergency Issue No. 10), pp. 340-341. Relation between pen record and bearing area; existing methods of specification of roughness. Paper for Symposium on Surface Finish. (ASM)

55-45. "A Short Review of Surface Finish in Relation to Friction and Lubrication"—D. Clayton; *Journal and Proceedings of the Institution of Mechanical Engineers,* v. 153, 1945 (War Emergency Issue No. 10), pp. 332-334. Surface roughness as a pertinent factor with boundary and dry lubrication and various practical cases of mixed lubrication. Paper for Symposium on Surface Finish. (ASM)

56-45. "A New Evaluation of Surface Finishes"—W. F. Klemm. *The Tool Engineer,* v. 14, n. 11, June 1945. Determination of surface finish by visual comparison with a known standard. The comparison is made with a dual microscope.



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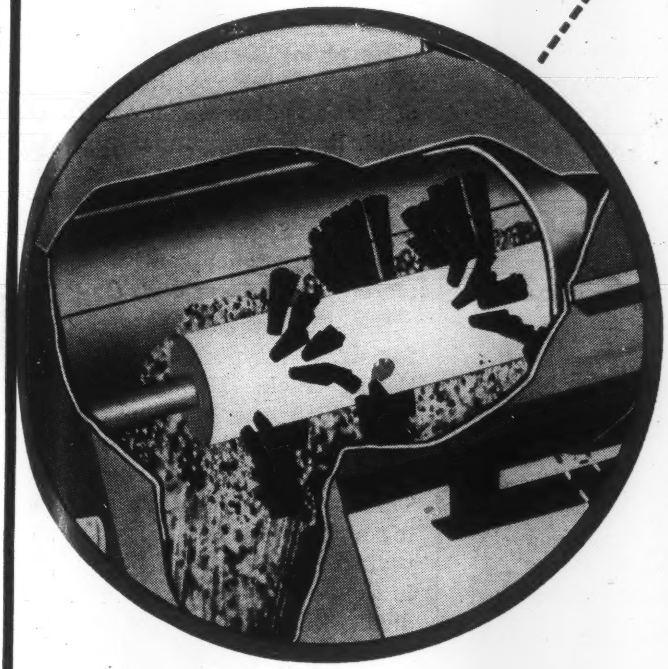

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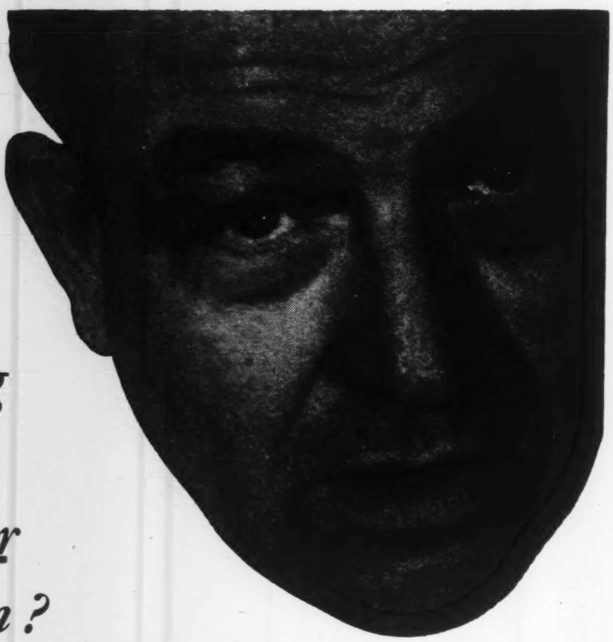

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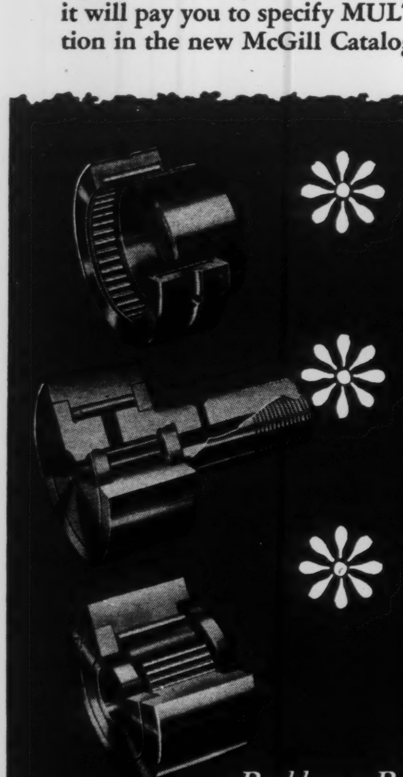

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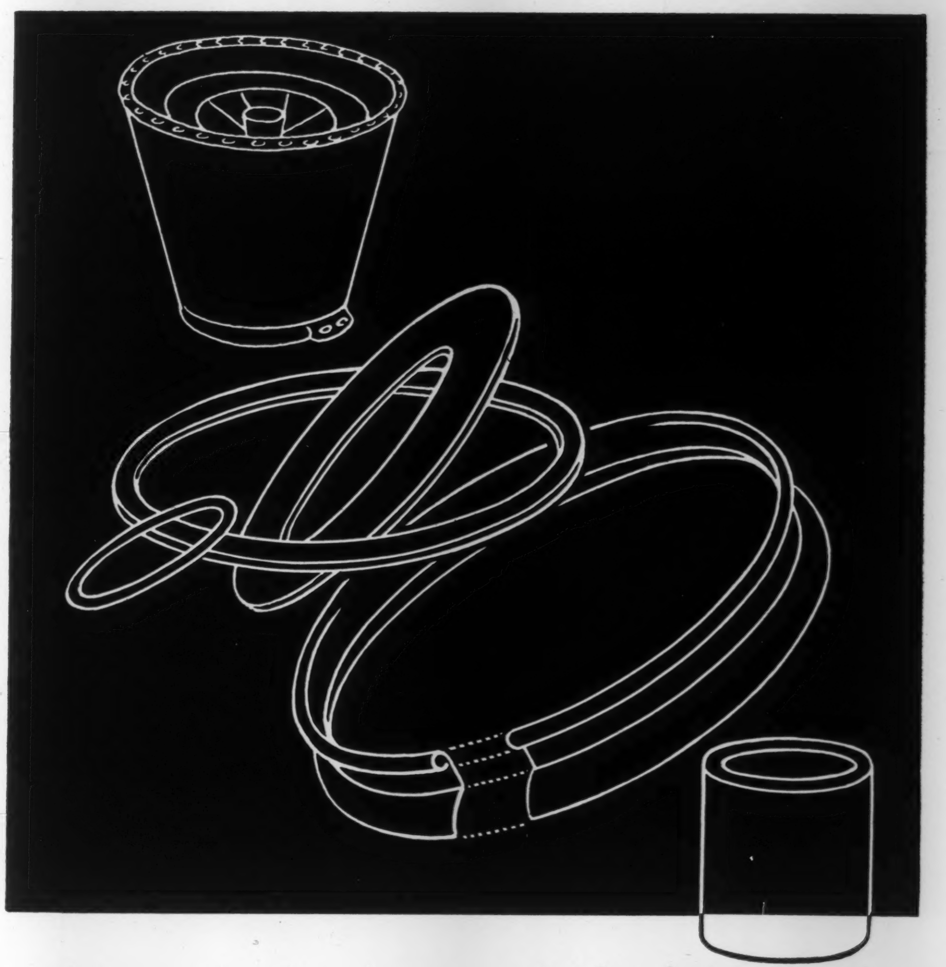

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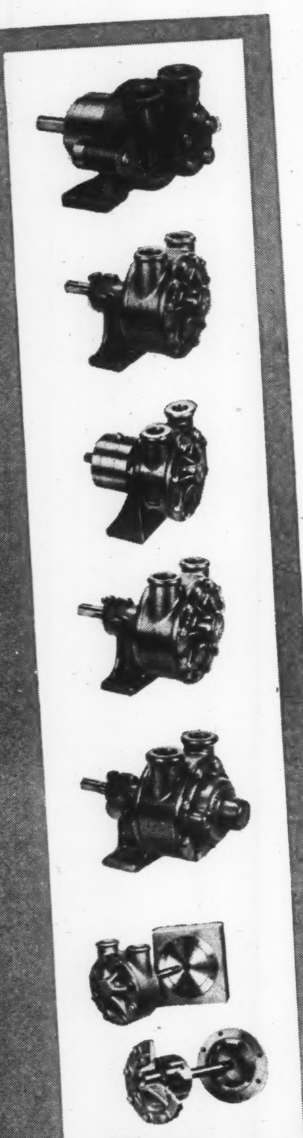

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Tuthill positive displacement internal-gear rotary pumps are serving industry on machine tools, engines, speed reducers, compressors, hydraulic mechanisms, special machinery and oil-burning equipment.

standard model would strike obstructions before the load could be elevated to the desired stacking height. Typical applications include loading and unloading box cars and van trucks, and working under low doorways, ceilings and balconies. Assemblies available in 92 and 116-in. lift heights; also available on special order in higher lifts. *Hyster Co., Portland, Ore.*

Metalworking

Grinding Attachment: For surface grinders. Makes possible grinding of cylindrical and angular forms. Index plate with 24 divisions is provided for grinding parallel flats or angles. Plates having up to 360 divisions are available. All indexing is done at handle end of spindle. Tapers can be held to closest tolerances through two-way, 5-in. sine bar arrangement, with which angles can be duplicated. Has spindle speeds of 200, 400 and 700 rpm. Capacity between centers, 7½ in. length, 6½ in. diameter; collet capacity, ⅝-in., with ½-in. hole through spindle. *The DoAll Co., Des Plaines, Ill.*

Hydraulic Contouring Attachment: For Springfield lathes for turning, boring and facing on shafts, axles, rotors and other parts with varying diameters, shoulders, tapers, radii and flanges. Supported and guided adjustable template holder places templates at the front of the lathe. Simple electromechanical speed control governs a variable-speed headstock drive motor and maintains constant cutting speed as the lathe follows varying contours. Changeover from standard operation to contouring is made simply by substituting the hydraulic compound rest for the standard rest. *The Springfield Machine Tool Co., Springfield, O.*

Center-Locating Vise: Centr-Finder consists of two opposed pneumatic cylinders mounted on a cast iron base with master jaws at the ends of the piston rods. Jaws travel along guides; movement of both jaws is mechanically syn-

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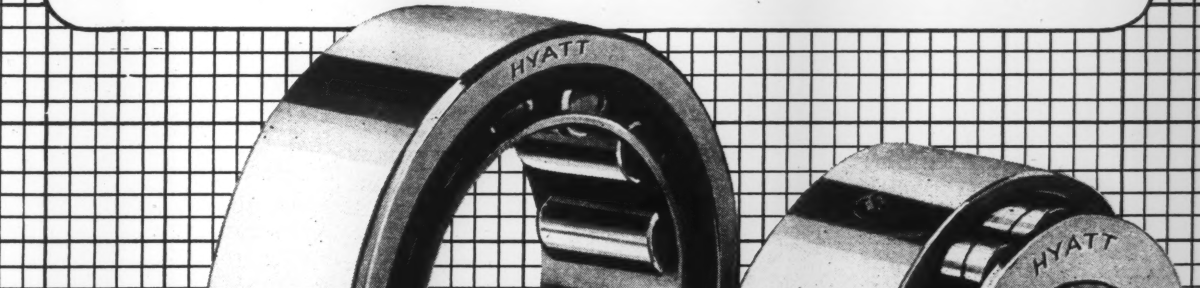

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BILLETS AND FORGINGS FOR PRODUCTION, TOOL ROOM AND MAINTENANCE REQUIREMENTS

chronized. Machine operates on 5 to 100 lb air pressure, depending upon the force desired at jaws. Delivered pressure on the work is the total pressure exerted by both cylinders. Clamping pressures up to 2000 lb may be obtained. Jaw tolerance from established centerline is plus or minus 0.001-in. at any dimension of jaw closing, with a working range of 0 to 4 in. Thus workpieces are centered horizontally and vertically regardless of shape. Jaws are independently adjustable from centerline to accommodate workpieces other than symmetrical. Requires less than 2 sq ft of bench space and one air line connection to a four-way valve. *Black Drill Co. Inc., Cleveland, O.*

Mortising Attachment: Consists of fence assembly which bolts to drill press work table, a mortising chisel holder which clamps to drill press quill, and mortising chisels and bits in 1/4, 3/8 and 1/2-in. sizes. The two guide arms, which are attached to the fence, adjust separately to handle irregularly shaped pieces. Fence has 1-in. independent adjustment on the base. These flexible adjustments give attachment up to 5 11/16-in. capacity under forked hold-down and as much as 4 7/16-in. between guide arms and fence. *South Bend Lathe Works, South Bend, Ind.*

Honing Machine: Bench model for production honing of keyways, spline gears, most broken surfaces and internal finishing operations. Features spindle speeds of 400 to 1000 rpm with no changing of belts, honing range from 0.185 to 2.500 in. in diameter, permanent mandrels that fit spindle with bayonet lock. Has 1/3-hp, 110-v. 60-cycle, single-phase motor. Size: 25 in. high, 13 in. wide, 16½ in. deep. Companion portable coolant unit available. Adaptable to any dry honing machine; mounts on brackets. Weighs 44 lbs, has splash pan 21¼ by 30¼ in. *Superior Hone Corp., Elkhart, Ind.*

Precision Thread Grinder: Large capacity machine for grinding threads, worms and other forms. Grinds single or multiple threads, left or right-hand, in any pitch

Advertisement

SILICONE "O" RINGS

Good News For Today's Designer

Results from a recent survey show the successful use of a variety of silicone compounds in seal applications never attempted before with a resilient material because of temperature limitations. According to Linear, Incorporated, of Philadelphia, Pa., a principal manufacturer of "O" Rings, one group of silicone compounds have been designed for general use at temperatures ranging from −65° to +500°F. Modifications of the general purpose stocks have produced several compounds with extreme low temperature flexibility. Other types possess a maximum resistance to compression set over a wide temperature range.

Chart Tells The Story

SILICONE RUBBER STOCKS

Linear Style No.	Hardness Shore A Scale	Tensile Strength Min. (P.S.I.)	Elongation Min. (%)	Temp. Range (°F.)	Compression Set*	Color
ZK-50	50	400	100	−65 to +400	10 to 20	Red
ZA-60	60	400	150	−65 to +400	50 to 70	White
ZM-70	70	500	75	−65 to +400	15 to 25	Gray
ZN-80	80	600	50	−65 to +400	20 to 35	White
ZT-60	60	350	130	−125 to +400	30 to 50	Red
ZD-60	60	350	150	−85 to +400	40 to 60	Red
ZG-45	45	550	250	−125 to +400	40 to 60	Red-Tan
ZJ-60	60	500	70	−65 to +400	20 to 30	Red
ZP-80	80	550	50	−70 to +400	60 to 80	Gray
ZS-80	80	550	50	−70 to +400	25 to 30	Gray
ZU-50	50	600	225	−65 to +400	65 to 75	Neutral

* Method B 22 hours at 300°F.

Notes:

1. *Temperature range values are based on actual experience in the field and the silicone rubber will perform very satisfactorily within these ranges over long periods of time. Intermittent temperatures as high as +500°F. are not harmful in most applications, but will shorten the ultimate life of the rubber.*
2. *All other values were determined at room temperature according to A.S.T.M. procedure. For silicones, room temperature values are retained with relatively little change over a wide temperature range. Therefore, they can be used with some assurance in selecting compounds for specific applications.*

Successful Usage Today

Silicone "O" Ring gaskets have proven to be highly successful as static sealing parts on a wide variety of equipment subject to extreme temperature conditions, oxidation, or to prolonged weathering. Silicone seals are giving outstanding service on certain types of aircraft shut-off valves which control the in-take of hot air from the intermediate stages of jet engine compressors under 500°F. operating conditions. Further investigation indicates the use of silicone "O" Rings on outdoor flood-lights, steam irons, transformers, geophysical equipment and diesel engines.

Research For Tomorrow

Linear Incorporated is continuing its Research Program to develop new silicone seals to meet the increasing demand for elastomers having a wide variety of physical properties. The future indicates that there will be expanding requirements for the many advantages offered by silicone as an outstanding engineering material for sealing purposes.

GASKET SPECIFICATIONS:

- MUST WITHSTAND TEMPERATURE VARIATIONS OF −125°F. to +400°F.
- MUST BE MOISTURE RESISTANT
- MUST WITHSTAND SEVERE THERMAL AND MECHANICAL SHOCK

LINEAR

SILICONE "O" RING GASKETS MEET TOUGH SPECIFICATIONS

LINEAR Silicone "O" Rings help the design engineer solve any number of unusual specifications. The ability to withstand extremes in temperature, for example, is typical of the high flexibility of this seal.

In this application, the need was for a gasket with a flexibility that could resist heat as high as +400°F. or cold as low as —125°F. Complete elimination of moisture, oxidation, thermal and mechanical shock to lens and bulb of the searchlight was an absolute must.

The sales potential of this product has been strengthened with LINEAR Silicone "O" Ring Gaskets. No longer do gaskets deteriorate rapidly, permitting moisture to enter socket . . . no longer do bulbs break because of thermal or mechanical shock . . . no longer is it necessary to replace gaskets whenever a bulb needs replacing. LINEAR "O" Rings keep a tight, moisture-proof seal throughout all extremes of weathering—they do not become gummy or stick at high temperatures.

To lower costs and reduce sealing maintenance, consult LINEAR for all your sealing requirements.

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LINEAR

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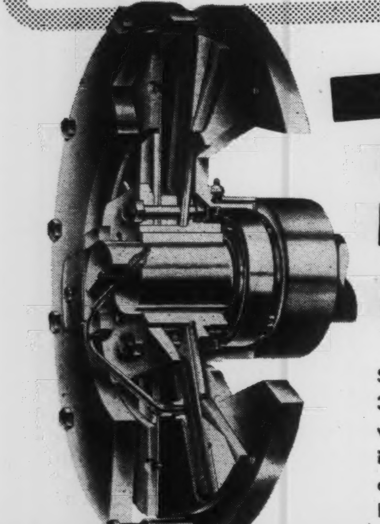

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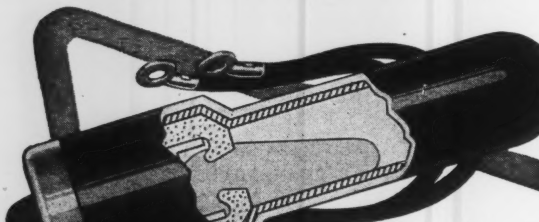

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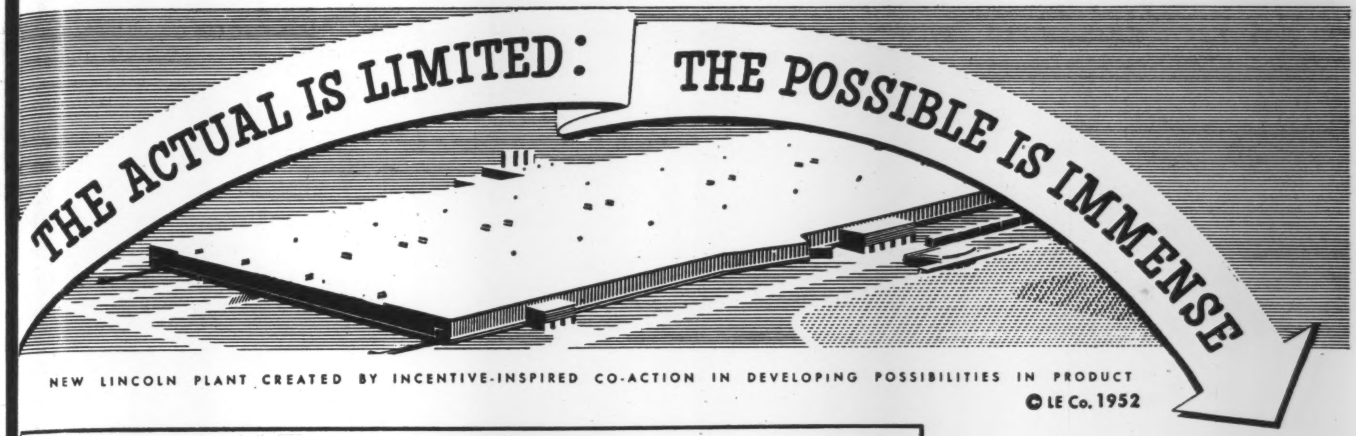
from 1 to 128 threads per inch. Can be used with single or multiple-rib grinding wheels. Attachment for grinding internal threads also available. Work spindle can be indexed for grinding multiple-start threads and worms. Automatic indexing attachment also available. Automatic functions include feed to finish size, wheel dressing, wheel-position compensation and resumption of grinding cycle after dressing, backlash compensation, control of coolant flow, lubrication, and wheel retraction at the end of grinding cycle. *Ex-Cell-O Corp., Detroit, Mich.*

Backstand Idlers: For polishing, grinding, etc. Air-operated cylinder maintains a constant preset tension on abrasive belt. Regulating valve enables operator to match tension requirements. Air cylinder acts as shock absorber. Model 505 has large rectangular base with four slotted bolt holes so that distance of idler unit from contact wheel may be initially adjusted without removing bolts. Size: 40⅜ in. high, 22 in. wide, 34⅜ in. long, 35⅝ in. high from floor to center of idler pulley; weighs 260 lb. Model 510, with wall mounting, is 27 in. high, 19 in. wide, 30½ in. long; weighs 215 lb. Specifications of both models include: Idler pulley diameter, 8¾ in.; idler pulley width, 6 in.; lateral adjustment to align with drive pulley, 2½ in.; speed, up to 10,000 sfpm. *Porter-Cable Machine Co., Syracuse, N. Y.*

Surface Grinder: For toolroom and production work. Has wheel 10 in. in diameter by 1 in. wide mounted on a 2-in. diameter spindle 22 in. long, running at 1740 rpm. Diamond truing device is mounted on wheelhead. Table has working surface 8 by 18 in. and longitudinal travel of 19 in., operated either hydraulically or manually. Saddle has crosstravel of 9¼ in. Crossfeed is automatic in increments up to 0.050-in., actuated by trip-dogs with automatic disengagement at any desired point. Wheel for hand operation of crossfeed is calibrated in divisions of 0.001-in. in normal position; fine-feed device gives readings down to 0.0001-in. Wheel-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NEW LINCOLN PLANT CREATED BY INCENTIVE-INSPIRED CO-ACTION IN DEVELOPING POSSIBILITIES IN PRODUCT

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BUILDS STRONGER MORE RIGID MACHINE BASE

...cuts weight 36%, lowers cost 45%

By **A. H. Hallenbeck,** Plant Manager
Gifford Wood Company, Hudson, New York

WELDED design has been adopted on many of our machine components because of lower cost and better quality production with steel. As shown in the welded base (Fig. 2), lower weight with steel now saves on material cost as well as in transportation charges. Welded steel can be fabricated with simpler skills, helping to eliminate production bottlenecks in the shop. Components are pre-machined on light, fast machine tools prior to welding, saving time and cost of operating heavier shop equipment as was the case with cast construction.

Through welded steel, our shop now has better control of its work schedule. We are no longer dependent on outside sources for castings nor contend with storage and maintenance of pattern equipment.

Welded design makes it possible to meet price competition in our field that we were unable to do with the original cast designs. The product has a more modern appearance to improve selling appeal.

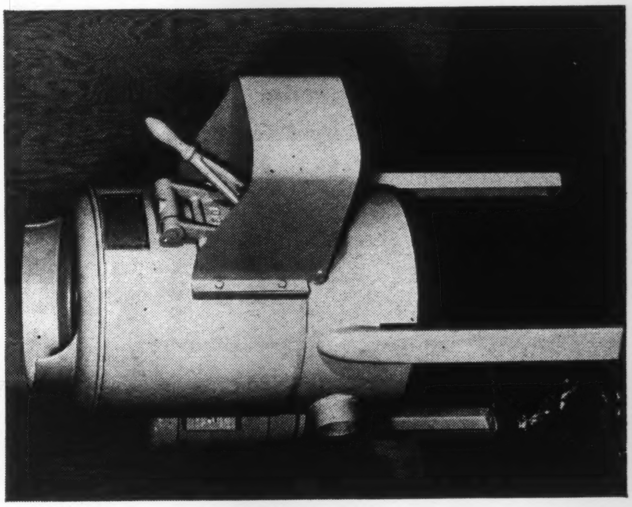

Fig. 3—Food processing machine *for the Gifford Wood Company, Hudson, New York. Streamlined appearance is simple to maintain, easy to clean.*

WELDED DESIGN ALWAYS SAVES STEEL AND LOWERS COST

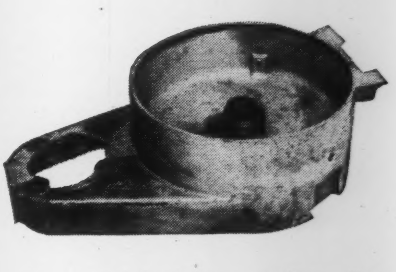

Fig. 1—Original Construction—*Base for processing machine. Weighed 67 pounds. Material Cost—$15.05; Machining Cost—$7.34. Total Cost $22.39.*

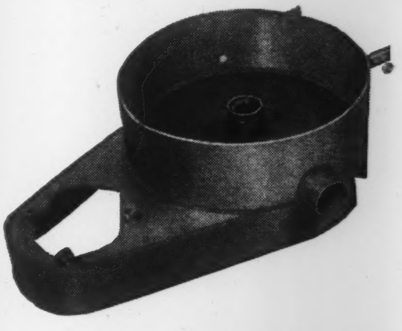

Fig. 2—Present Welded Steel Design—*Stronger, more rigid. Weighs only 43 pounds. Material Cost $2.50; Fabrication—$9.77. Total Cost—$12.27.*

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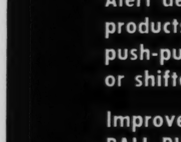

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head has power rise-and-fall mov ement operated by separate 1- motor for rapid setting; has max mum travel of 12 in., giving clearance of 10 in. between top the table and periphery of a ne wheel. Slideways have long, na row guides. Cross movement of sa dle is controlled by narrow guide i dependent of flat ways which carr the weight. Floor space require 81 by 60 in.; weight, 3920 l *Arthur Scrivener Ltd., Birmin ham, England.*

Punch Presses: Four or five-to capacity. Features include 12¾-i throat, variable-speed control b single adjustment for from 90 t 280 strokes per minute; ram clam with square hole adjusts from to 1 9/16 in.; clutch-drive safet shears at excessive overload; non repeat safety mechanism whic eliminates possibility of doubl trips; 3-in. drop in movable be to accommodate larger dies or di sets. Can be used for standard di space, extended die space, as a half press and as a horn press *Kenco Mfg. Co., Los Angeles, Cali*

Testing and Inspection

Torque Tester: For measuring torque transmitted through smal instrument ball bearings unde thrust loads. Quality control check shows how torque of a small bal bearing varies as a function o angular position during a continuous slow rotation in either direction. Determines bearing torque by measuring current drawn by a torque motor in counterbalancing the bearing race torque as indicated by an electromagnetic pickup. Can determine number and magnitude of peaks, average friction, and tendency to bind under load. Bearing to be tested is inserted in an adapter and both are then mounted in tester. Inner race is clamped to shaft of the device; outer race is rotated one revolution in either direction by a drive motor. Torque from outer race is transmitted through ball bearings to inner race and shaft, tending to rotate shaft assembly and angularly displace an electromagnetic pickup. A signal

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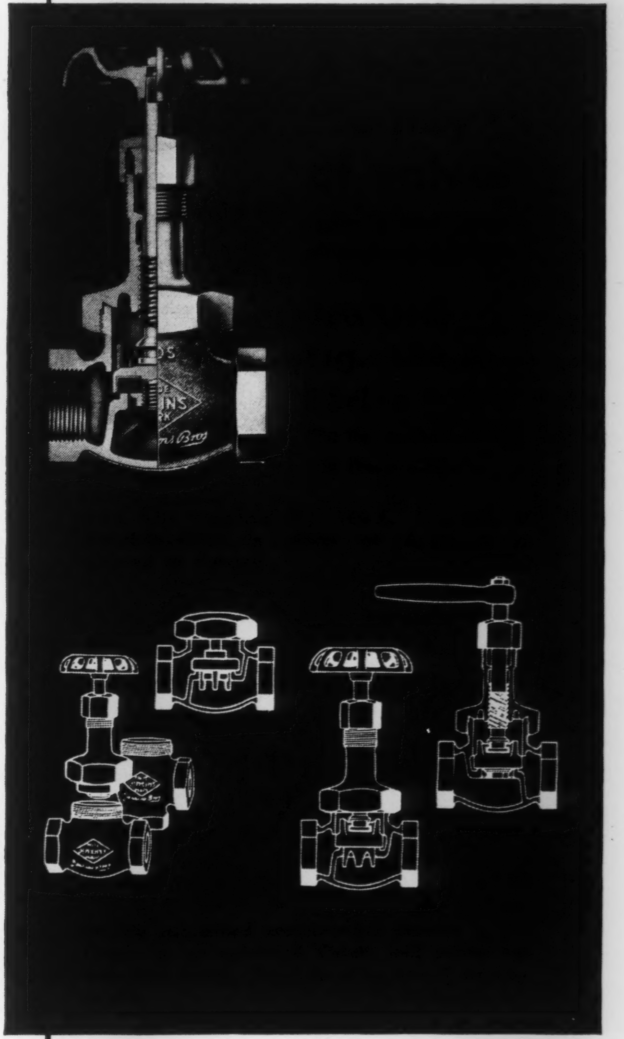

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Compact, economical constant-volume pumps of high efficiency. Hydraulically balanced axial-piston design. Three models offer capacities ranging to 3000 psi, 1800 rpm, 9.5 gpm. Catalog P-4-10

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A fixed-stroke axial piston motor with high torque of 510 inch-pounds maximum — about 24 hp. Operates at maximum 3000 rpm; pressures to 2500 psi. Small, compact, efficient. Catalog FM-2

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Rugged, hydraulically balanced, 4-way valves for all requirements to 5000 psi. Seven standard spool combinations; threaded or subplate body types. Seven types of controls for valve operation — manual, hand lever, mechanical stem or cam, hydraulic pilot with or without throttle control, and single or double electric solenoid. Catalogs VD-3, VD-2, VD-4

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A solenoid-controlled 4-Way Valve that eliminates spool-sticking during long, high-pressure holding cycles. System pressures shift valve spool; solenoid operates pilot valving only. Catalog VD-1-1

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Denison relief, sequence and unloading valves provide closer control of system pressure with low differential between opening and closing pressures. Available in three pressure ranges for circuits developing up to 5000 psi. Choice of threaded body, subplate, or flange-type mountings. Catalog VR-2A

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Self-contained, vertically mounted units for 2 to 11 gpm requirements. Single-panel assembly of operating components. 15 models cover any circuit need from 400 to 3000 psi. 16 to 35-gallon reservoir capacities. Automatic water-cooled oil coolers available for heavy, continuous service. Bulletin PU-3

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High-pressure pumping units in 22 models for circuits up to 5000 psi. Axial piston pumps. Constant or variable-volume delivery of 10, 20 and 35 gpm . . . volume control by handwheel, stem, or pressure compensation. All operating components mounted on reservoir top. 2-pass automatic heat exchangers, available for extra heavy duty. Bulletin PU-4

proportional to this displacemen
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6 by 9½ by 6 in.; weighs, 13½
Size of electronic unit, 17 by 8
by 9½ in.; weight, 21½ lb. Size
recorder (optional with tester),
by 13 by 11 in.; weight, 35 lb. *Ge
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N. Y.*

Welding Analyzer: Direct-wr
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phase and three-phase resistan
welding machine variables. Cu
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and show squeeze, weld, hold, an
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writing oscillograph. Analyzer ca
record at 180-cycle per second fre
quency for three-phase timing pur
poses. Operating variables of re
sistance, spot, projection and sean
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Cleveland, O.*

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Measures surface electrical resist-
ance, directly in microhms, as a
criterion of the effectiveness of a
cleaning process. Designed for
measuring resistance of aluminum;
also measures other materials with
low surface resistance. Directly
measures total surface resistance
of two sheets, or coupons, when
placed between two self-contained
electrodes. Resistance values of 0
to 100 microhms can be read direct-
ly; resistance of 100 to 1000 mic-
rohms may be read indirectly. Re-
sistance as low as one-millionth of

Longer Life...

designed and built for *extra* operating stamina

"The Finest Money Can Buy!"

TRADE MARK DENISON HydrOILics

PUMP/MOTOR

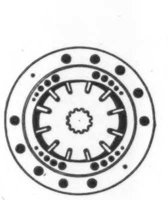
For circuit needs up to 2000 psi

Every feature of Denison's compact, dual-purpose Pump/Motor is designed to *stand up longer* under continuous, heavy-duty service at 2000 psi.

Hydraulically balanced vane and rotor action means smooth, uniform, radially balanced operation. It assures minimum wear on both the vanes and the cam ring, and reduces surge and pulsation to a minimum. For added assurance of higher efficiencies, vanes are designed to contact the cam ring with *dual sealing edges.*

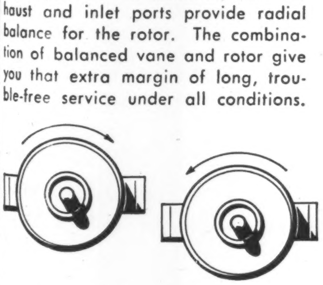
Four sizes, each offering a series of interchangeable cam rings, provide capacities to meet your specific need. Operating at 1200 rpm and 2000 psi, they offer pumping capacities from 2.7 to 70 gpm. As *motors,* their torque ratings range from 13 to 257 pound-inches per 100 psi. And all models are *ready to operate* as either pumps or motors, without alterations of any kind.

Wherever you need rugged power for circuits developing up to 2000 psi, Denison Pump/Motors offer the finest money can buy. Write today for bulletin P-5.



Complete Radial Balance

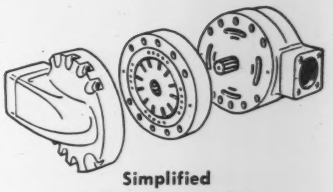
Hydraulically balanced vanes reduce load on the cam ring and *retain low loading characteristics* at *all* operating pressures. In addition, twin exhaust and inlet ports provide radial balance for the rotor. The combination of balanced vane and rotor give you that extra margin of long, trouble-free service under all conditions.



Bi-Directional Operation

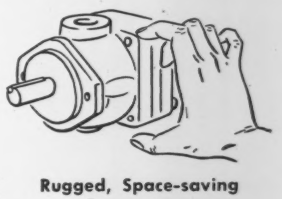
All Pump/Motor models may be used for either clockwise or counter-clockwise rotation—operating with equal efficiency in either direction!

"A SIZE FOR
EVERY NEED"



Simplified 3-Unit Construction

Simplified construction featuring only three major components — with interchangeable cam rings for each different pumping cartridge — add still further to the versatility and long service life of Denison Pump/Motors.



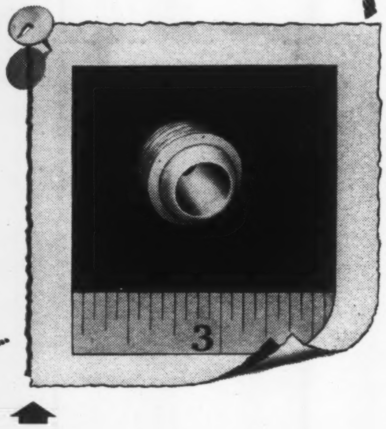
Rugged, Space-saving Compactness

Compact construction makes Denison Pump/Motors easier to adapt to any circuit plan. Model TMB12, shown above, delivering up to 7.5 gpm at 2000 psi is only 4⅛" high, 4⅛" wide, and 8" long including the shaft.

The DENISON Engineering Company

1156 Dublin Rd., Columbus 16, Ohio

for
product improvement
ideas consider
nylon
rod and strip



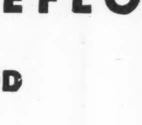
This valve seat machined from FM-10001 nylon rod outlasts 3 to 5 seats made from metal. Because of its resiliency, plus resistance to abrasion and corrosion, this nylon seat is practically "leakproof". Machining was readily handled on metalworking equipment.

Nylon formulations with properties tailor-made for specific applications are available, and will provide the performance you need. Many products such as valve seats, bearings, gears, instrument and control parts are now being made from several nylon formulations, because of the material's outstanding physical properties.

Nylon rod and strip made to meet your job requirements can give you important savings in fabrication. You start production immediately, right from the blueprint. No waiting for expensive molds. Design changes can be made quickly, and the tooling costs are low.

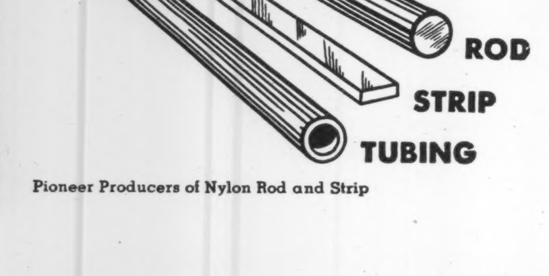
Folder Describes Types and Sizes Available . . .

Just drop us a line for your free copy of this folder describing various nylon formulations, sizes available, etc.



THE POLYMER CORPORATION
Reading, Pa.

NYLON
& TEFLON



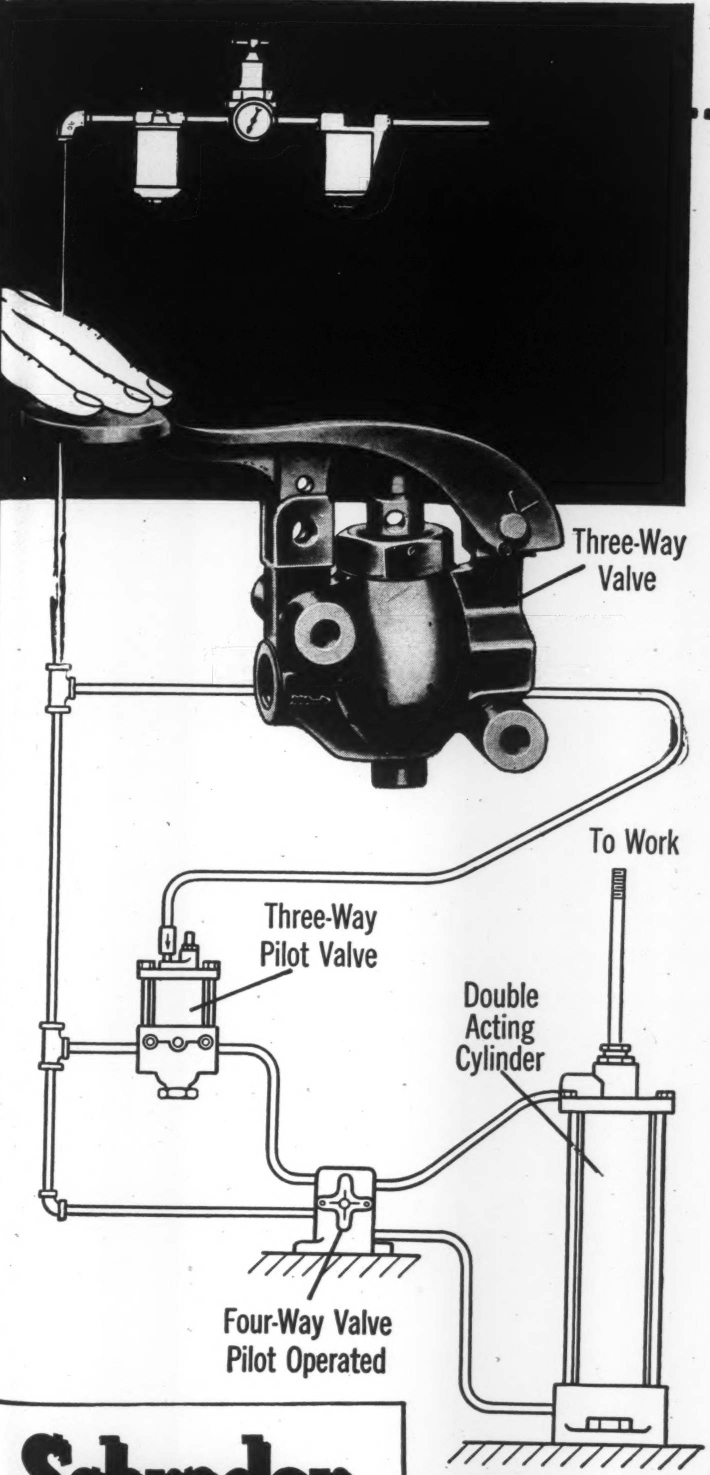
Pioneer Producers of Nylon Rod and Strip

an ohm can be measured on a direct reading linear scale calibrate 0 to 100 microhms. Indicator ha hydraulic pressure device and pressure gage, 3-in. standard coppe electrodes, vacuum type dc millivoltmeter, resistance indicator adjuster, and dc power source wit suitable voltmeter and indicato bulb. Size, 13 in. high, 20 in. wide 10 in. deep. Available shock mounted on caster type cart; overal dimensions with cart, 48 in. high 24 in. wide, 18½ deep. *Weltroni Co., Detroit, Mich.*

Illuminated Magnifier: Mode 66SV portable high-intensity fluorescent fixture for industrial inspection. Equipped with either a 2 or 4-power lens 2 by 4 in. in size. Lens holder is hinged so that light can be used with or without the lens. Lens also acts as chip shield when in use. Equipped with either a heavy portable cast base or, for a more permanent installation, can be supplied with longer arms for machine or bench mounting. *Stocker & Yale Inc., Marblehead, Mass.*

Internal Inspection Instrument: Long tubular Borescope can be used to investigate and inspect inside walls of surfaces of hollow castings such as engine cylinders, crankcases, etc., which are accessible only through a small hole. Internal walls appear magnified in large optical field of instrument. Tube diameter is ½-in.; various lengths from 20 in. are available. Contains a set of twelve highly corrected, achromatized, fluoride-coated lenses whose field of vision is approximately 30 degrees (included angle). Magnification ranges from 2x at target distance of 12 in. to 6.25x at 3 in. Entire inner wall of a hollow part can be inspected by inserting instrument to various depths and by rotating it around its own axis. Has built-in illumination which can light a comparatively dark surface at several inches distance. *Testa Mfg. Co., Los Angeles, Calif.*

Surface Comparator: Faxfilm Model BL-122. Clear plastic replica of a surface is made and projected in a microprojector to show minute details of surface condition with



-Air Control Starts with Schrader Valves

To use work ejection . . . clamping . . . and the numerous pneumatic sequence controls that work wonders in the average plant, you need reliable valves.

That's where Schrader Valves come in. Whether your air equipment is actuated by hand, foot, cam or tripper, you'll find a Schrader engineered valve that exactly fits your needs.

With over a hundred different models to choose from . . . each functionally designed to cover a broad range of applications . . . you'll have no trouble finding just the valve you need —one that is compact, easy to install, simple to maintain.

Each Schrader Valve is individually tested to full pressure rating before it is shipped. That's why you're sure of reliable service from every valve that bears the Schrader name.

Whatever production layout you are designing, it's nearly certain that air will play a big part in making the installation a success. And, wherever you design for air, remember—Schrader Valves.

To see how truly practical Schrader Valves are . . . how you can't help but benefit from their use, write, describing your contemplated air use—or fill out the coupon below.

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